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INSTRUCTION MEMORANDUM
HISTORY OF THE DEVELOPMENT OF FIELD
ARTILLERY MATERIEL



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INTRODUCTION

1. **Value of the historical background.**—A comprehensive study of any subject should begin with its historical development. In the case of field artillery materiel, a superficial examination of museum curiosities is not sufficient. The survey, to be of real value, must identify in each discarded type the fundamental principles which remain unchanged in the evolution of armaments. These principles are more easily discerned in the simpler weapons of yesterday than in the complex constructions of today. We are inclined to assume, unless we are given the historical background, that current problems are entirely new. History discloses that most of these problems occurred and recurred in the past. An understanding of how they were decided by previous generations of artillerymen, under the conditions then existing, will assist us in avoiding many pitfalls in the present and in the future.]

2. **Relation of materiel to tactics.**—[Weapons and tactics are mutually dependent. It is said that every mechanical development is the result of a battlefield demand. It is equally true that

many demands remain unsatisfied. Centuries pass before scientific and industrial facilities can materialize the dreams of antiquity. On the other hand, an unpredicted discovery occasionally surprises the strategists and tacticians, causing a revolution in the art of waging war. In such cases it may be said that tactics is forced to conform to materiel, rather than materiel to tactics. Both must conform eternally to "the face of nature and the heart of man." Bearing that in mind, we may say more specifically that the development of armament proceeds as a tactical compromise between the considerations of destroying power, mobility, communication, and procurement.

3. Chronological periods.—The historical development presented in this chapter is arranged in chronological periods. It must be remembered that these periods overlap, and that most changes were of gradual, not sudden, accomplishment. Because both artillery materiel and tactics have been vitally affected by contemporary developments in infantry weapons, the most important of the latter will be briefly reviewed. The facts and dates are obtained from the sources listed in the appended bibliography. The chronological division adopted is as follows:

- a. Pregunpowder period (prior to 1250 AD).
- b. Early smoothbore period (1250-1630).
- c. Late smoothbore period (1630-1860).
- d. Transitional period (1860-1897).
- e. Modern period (1897-1939).

PREGUNPOWDER PERIOD (PRIOR TO 1250 AD)

4. Earliest records (Fig. 1).—Engines of war for throwing missiles beyond the range of hand weapons were known in the earliest times. The Scriptures record their use on the walls of Jerusalem eight centuries before the time of Christ. Such machines were artillery in the true sense of the word, both in tactical handling and material effect upon the enemy. Most were variants of the catapult and ballista, which utilized the elasticity of twisted ropes of hair, hide, and animal sinews for the energy of propulsion. In the ballista, a relatively flat-trajectory weapon, two horizontal arms pulled a cord, somewhat like a crossbow, to

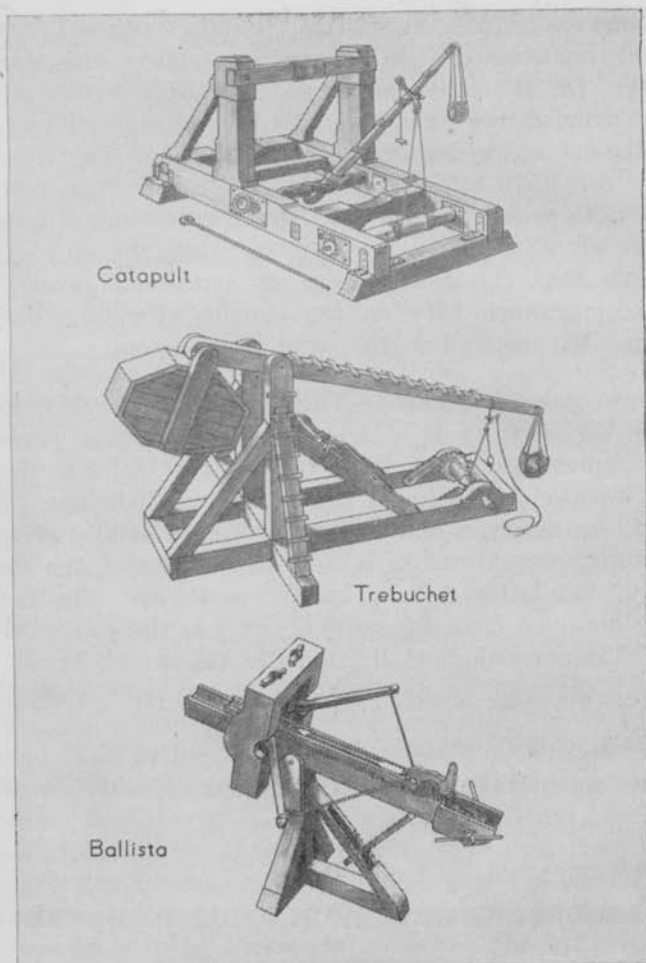


FIGURE 1.—Pregunpowder weapons.

fire arrows, darts, and stones. It had devices for laying in elevation and direction, and was employed much as the light field gun of later times. The catapult, a curved-fire weapon, usually consisted of a single upright arm, swinging in a vertical plane, having at its outer end a cup or sling. Throwing stones or incendiary matter, it executed missions similar to those assigned the mortar or howitzer of today. Missiles weighing as much as 100 pounds or more could be hurled a distance of 600 yards.

5. **Artillery of the Greeks and Carthaginians.**—Philip of Macedon found the principal use of artillery in sieges, but he also organized units for mobile warfare that were used by his son Alexander (356-323 BC) to master the world. In the era following Alexander's conquests, Greek scientists in Alexandria invented marvelous engines of war employing principles which did not reappear for 2000 years, such as repeating weapons firing projectiles from magazines. A Greek named Ctesibius is said to have utilized compressed air for the energy of his catapults, the arms of which worked in carefully wrought cylinders. Archimedes in the defense of Syracuse (214-212 BC) confounded the Romans with long-range fire from his personally designed engines, sinking their ships and destroying their own cruder devices. Some indication of the number of such machines employed may be obtained from the Roman inventories after the capture of Carthage, which indicate that the Carthaginians had about 10 catapults for every 1000 foot or horse soldiers, an artillery proportion greater than that found in a modern infantry division. Artillery duels are recorded which were strikingly similar to those of today.

6. **Artillery of the Romans.**—The Romans made extensive use of catapults and ballistas. Julius Caesar relates that in 57 BC, against the Belgians, he protected the right flank of his army by digging a trench with redoubts at the extremities in which he posted his machines so as to enfilade the trench. Two years later he covered the landing in Britain with fire from catapults and ballistas. By the year 67 AD this form of artillery was an organic arm of the Roman Legion. Transportation was by mule-drawn carts. For the upkeep of arms and engines of war the Legion had a detachment corresponding to our modern ordnance maintenance company.

7. **Medieval weapons.**—In medieval times, in addition to the devices inherited from the Romans, there was employed for siege purposes a form of catapult known as the trebuchet. It operated on the counterpoise principle, swinging a long throwing arm by means of weights on the shorter arm. Weights used sometimes exceeded 10 tons. The mass projected could amount to about five percent of the tonnage of the counterweight. A heavy trebuchet could hurl a 300-pound stone a distance of 300 yards. Long after the introduction of gunpowder, such machines con-

tinued to be used side-by-side with cannon, being superseded by the latter very gradually. A full century passed before they disappeared (FIG. 1.) As applied to small arms, the ballista principle was utilized in the form of the bow. About 1000 AD the velocity of the missile was increased by the adoption of the cross-bow.

8. **Summary of the pregunpowder period.**—Artillery consisted of the personnel and materiel for propelling large missiles, or for propelling small missiles to ranges beyond the possibilities of hand weapons. The problem has always been that of the concentration and sudden liberation of easily obtainable and transportable energy. The ancients employed to the best advantage the form of energy available to them; namely, muscular. This was applied in the elasticity of solids such as hair, hide, horn, and wood, or in the force of gravitation, as exemplified by the counterweight. Although the devices used were relatively crude and the ranges short, history shows that in this, the longest period of recorded warfare, the fundamental principles governing modern artillery tactics and materiel were laid down.

EARLY SMOOTHBORE PERIOD (1250-130)

9. **Invention of cannon.**—The invention of cannon is usually credited to Berthold Schwarz, a German monk of the 14th century, but records indicate the use of gunpowder in the Moorish wars in Spain as early as 1247, at the siege of Seville. The Arabian madfa, a small wooden firing vessel, was probably the original cannon. The first definite description of a gun dates from 1313, and the earliest picture of one is found on a manuscript of about 1327, by which time the weapon was in general use. In exterior shape it was somewhat like a vase. The projectiles fired were iron darts, which were wrapped in leather to prevent "windage," meaning the leakage of propelling gas past the projectile. Stone shots and sacks or cans of scrap iron called "langridge," the forerunner of grape and case shot, were also fired. The extreme range of these early pieces was perhaps 700 to 800 yards. The propellant was ignited by thrusting red-hot bars or spikes into the charge through an aperture (FIG. 2).

10. **Period of the 100 Years War (1339-1453).**—During the 100 Years War cannon came into general use in northern Europe.

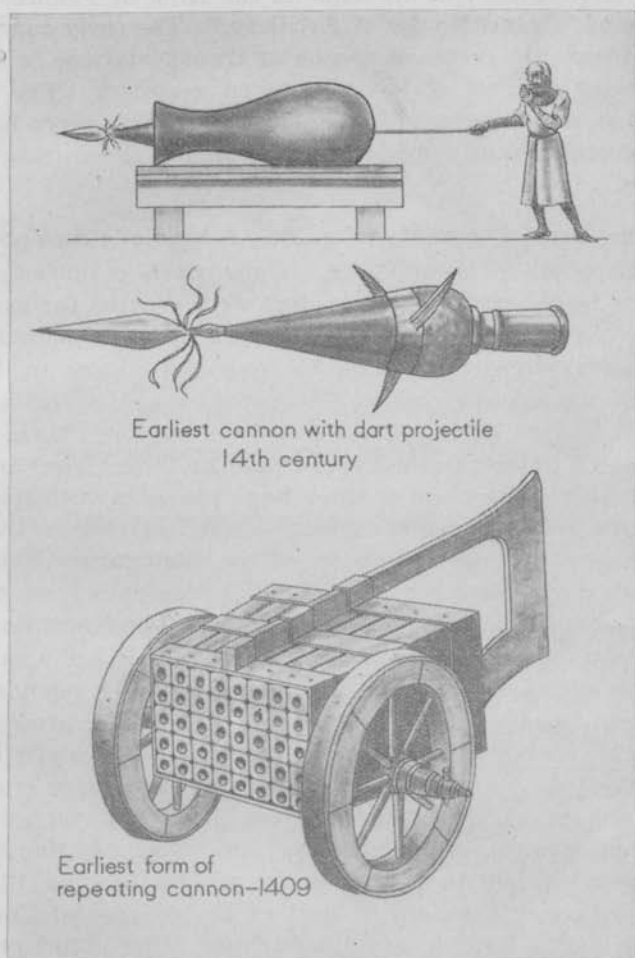


FIGURE 2.—Earliest forms of cannon.

By 1344 the ordnance establishment of King Edward III of England included 12 artillerymen and gunners. Two years later, at the Battle of Crecy, the English used guns for the first time in the open field. The cannon were placed directly on the ground, elevation being given by mounding up the earth or by supporting them with wooden blocks. From the year 1350, artillery development was given serious thought in all countries of Europe. To

push the development in his domain, the King of France created the office of "Grand Master of Artillery." The early cannon had no permanent gun crews or means of transportation, both being hired by the owners of the gun when required. The master gunner was a guildsman. Later, enterprising gunners had cannon built and rented them to customers for the duration of a campaign.

11. **The Great Bombards (Fig. 3).**—A headlong race proceeded in the direction of fire power. Guns were manufactured in larger and larger sizes until monsters were created far exceeding in caliber anything used in modern times. Because of their great weight, such pieces were valuable only for sieges or for the defense of towns. The expense of building and operating them could only be met by ruling princes, who employed them during the course of the next century to establish their power over the lesser nobility. The value of these huge pieces in battering down castle walls was perhaps the greatest single factor in the overthrow of the feudal system. Some of the giant cannon were castings; more frequently they were made of bars or rods of wrought iron welded together and bound with hoops. The Great Bombarde of Ghent, built in 1382, was of the latter type. It had a caliber of 25 inches and fired granite balls weighing 700 pounds. The Turks seem to have had a monopoly on the casting process prior to about 1471 when the art was introduced into western Europe. At the siege of Constantinople in 1453 the Turks used huge cast-bronze cannon, one of which weighed 19 tons and hurled a 600-pound stone ball seven times a day. The transportation requirements included 200 men and 60 oxen. As late as 1807 this ancient ordnance was used as part of the defense of Constantinople against a British naval squadron. One stone projectile cut the mainmast of the British flagship; another killed and wounded 60 men. A typical bombard is the famous Mons Meg, now exhibited at Edinburgh Castle. It is of the built-up rod construction, made in two sections which are screwed together. It is over 13 feet long and weighs five tons. With a powder charge of 105 pounds it could throw an iron ball 19½ inches in diameter to a maximum range of 1408 yards, or a stone ball to 2870 yards. This piece was used by the kings of Scotland to reduce the castles of rebellious nobles between 1455 and 1513. It was fired in the

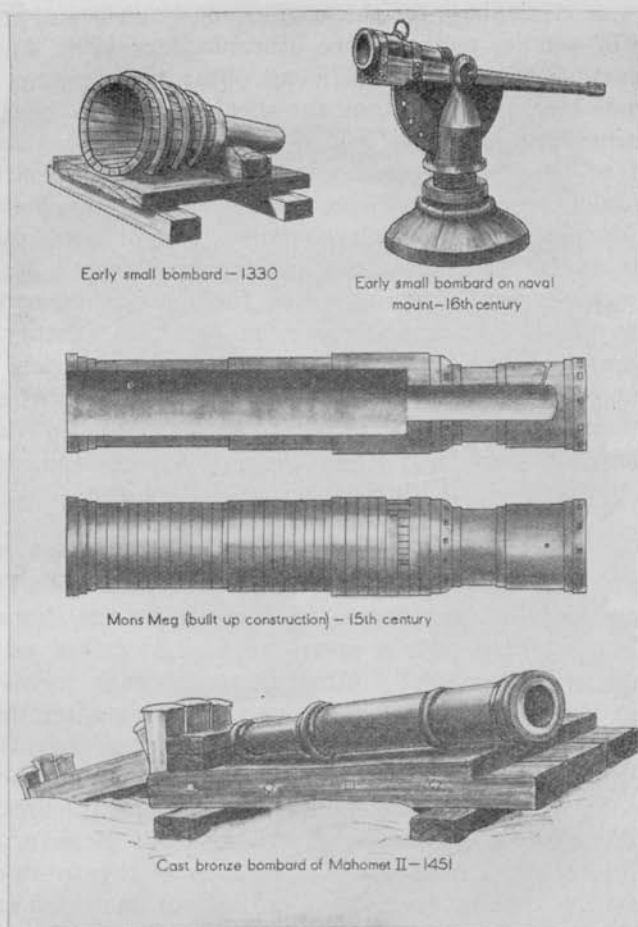


FIGURE 3.—Bombards.

defense of Edinburgh as late as 1650. The largest caliber gun on record was the Great Mortar of Moscow, built about 1525. It had a caliber of 36 inches, was 18 feet long, and fired a stone projectile weighing 2000 pounds. By that date, however, the development of musketry had forced the construction of lighter and more mobile cannon, bringing to an end the production of such unwieldy pieces.

12. **Early developments in design.**—The advantage of breech-loading was recognized by the earliest designers, and many of the guns of smaller caliber were breechloaders (FIG. 4). They did not survive because of inefficient obturation and the failure of the crude blocks to withstand the shock of firing. Early types of repeating cannon known as "ribaulds" also appeared. They consisted of bundles of small gun tubes clamped together and fired in quick succession. Some were mounted on wheeled carriages. Very early in their development, cannon were cast with trunnions, to facilitate elevation and transportation. Specialization of guns began. A small piece for mountain service was manufactured in Perignan, France, in the 15th century. This weapon was divisible into loads for pack transportation. Many early cannon burst in firing as a result of the efforts of enthusiastic gunners to get longer ranges. A distinguished victim of one of these accidents was King James II of Scotland, who was killed in 1460 while watching the test of a field gun.

13. **Early developments in ammunition.**—The first recorded use of explosive shell was by the Venetians in 1376. The projectile consisted of hemispheres of stone or bronze, joined with hoops. It was fitted with a primitive fuze described as "sheet-iron tubing with priming." Although occasionally mentioned in chronicles, shell was not in general use until long after that date. The Venetians introduced the method of igniting the propellant by priming the cannon vent with loose powder, and they were probably the first to put large cannon on wheeled mounts. Cast-iron solid shot was introduced about 1400, but stone projectiles continued to be popular for a long time because they were cheaper to manufacture and because, being only about one third as heavy as iron, they required less powder to propel them. Experiments with rifled small arms were begun as early as the 15th century, but the first successful use of rifling is not of record for another 100 years. By 1450, "corned" or granular gunpowder was introduced. The first recorded use of case shot, consisting of balls fired in a container, was at the siege of Constantinople in 1453. In the 16th century a celebrated Pole, Siemienowicz, "the father of Pyroballists," recommended a projectile that was a close approximation of the early form of shrapnel that appeared 200 years later.

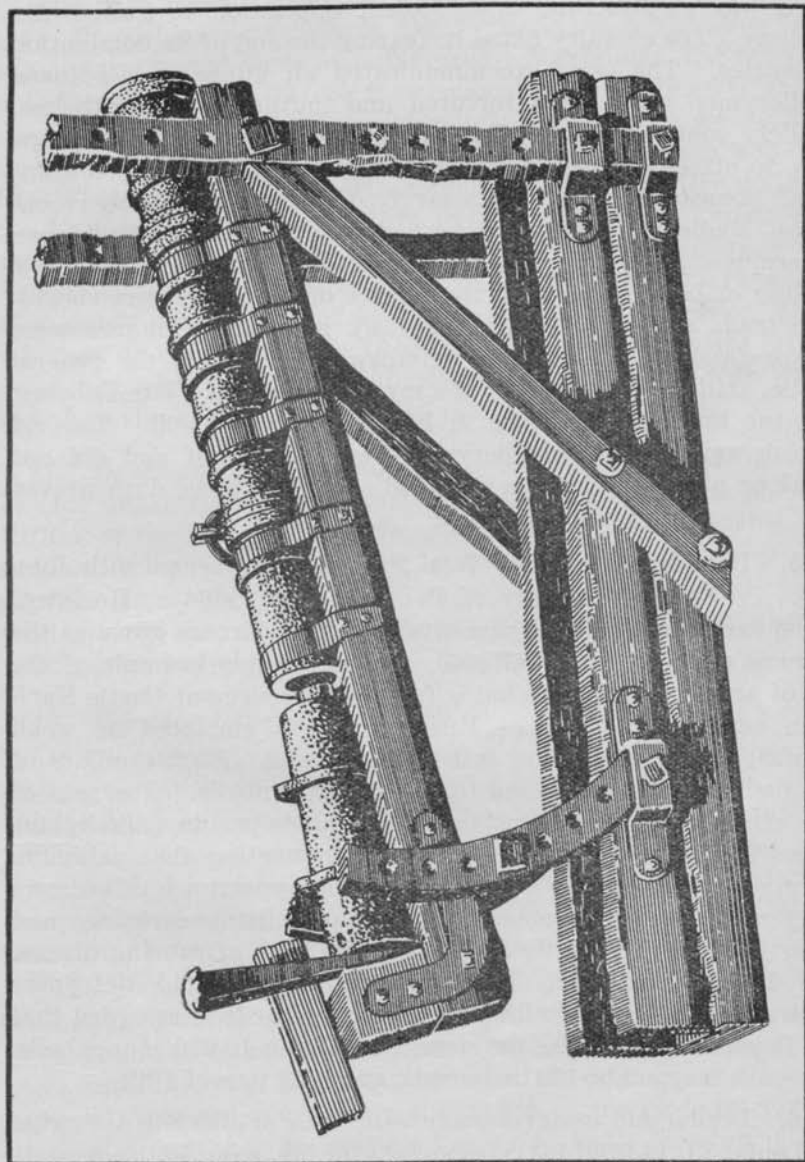


FIGURE 4.—Fifteenth century breech-loading gun.

14. **Public hostility to artillery.**—As with all new weapons, there was at first the most violent opposition to gunpowder artillery. The chivalry hated it, fearing the end of its domination of battles. The pope excommunicated all gunners. Captured artillerymen were often tortured and mutilated. Nevertheless, artillery continued to develop under the patronage of the kings, who, to offset the social onus, granted special privileges to gunners. Some of these privileges survived until comparatively recent times. Medieval artillery became a close corporation, with its own government and justice; the making of guns and gunpowder, the loading of bombs, and even the service of the piece were considered trade secrets and were jealously guarded. Gunners were not professional soldiers, but "civilian artists." By the general public, artillery was considered a mysterious science, like alchemy, and the gunner a sorcerer in league with the devil. The old records say that the artilleryman kept to himself and did not drink or plunder, which to the good soldier of those days proved that he was hardly human.

15. **Bohemian artillery.**—Real field artillery began with John Zizka in the Hussite Wars of Bohemia (1419-1424). He introduced carts for the rapid maneuvering of his bronze guns, as the Romans did with their ballistas. An interesting example of the use of artillery of this period is found at the siege of Castle Karlstein near Prague, by the Hussites. They emplaced 46 small cannon, five large cannon and five catapults. Marble pillars of Prague churches were used to supply cannonballs. The rate of fire of the heavy pieces was one to two shots per day, the lighter pieces six to twelve. It is especially interesting that catapults were still being used a century after the appearance of cannon. They were employed principally to hurl rotting carcasses and other filth into the castle confines in the hope of causing disease and breaking morale. In this case the intrepid defenders neutralized the bursts with lime and arsenic. It is recorded that the Hussites had to raise the siege after firing 10,930 cannonballs, 932 stone fragments, 13 fire barrels, and 1822 tons of filth.

16. **Leadership in development.**—French artillery in the reign of Louis XI (1461-1483) began one of its runs of leadership. The Frenchman's pride of those days consisted of 12 bronze cannon called the "Twelve Peers of France." Charles V of Spain

later produced a set which he piously called the "Twelve Apostles." Construction boomed after the introduction of bronze casting in 1471, flourishing especially in the Netherlands, where the best guns of the period were manufactured. Maximilian I, Emperor of Germany, about 1509 took the armament leadership away from the French. Some of the great minds of the Renaissance, including Leonardo da Vinci, interested themselves in cannon, and the importance of the arm in battle increased. Artillery fire decided the Battle of Marignano in 1515 by preparing the way for the shock action of infantry and cavalry. German gunners were considered the best in Europe. Maximilian's guns had a range of 1500 yards with solid shot and 400 yards with case shot. This was just about as much as field guns could do 350 years later. Solid shot were usually of cast iron or stones covered with lead, but plain stones were still fired in pieces of older model.

17. Developments in small arms.—About 1500 the first successful infantry firearm appeared, the matchlock arquebus. Rifling of the bore was experimented with in these weapons, the grooves being straight. The crossbow, however, remained supreme as a small arm, being improved by the substitution of steel springs for the old wood-horn-sinew bow. The Genoese were particularly highly rated as crossbowmen.

18. Service of the piece in 1500.

a. Up to this time, the lighter cannon, although nearly always present in battles in a great variety of shapes and calibers, were chiefly valuable for moral effect. They were mounted on stationary wooden frames, and once emplaced were practically immobile. An advance by the enemy resulted in their capture. Service of the piece was attended by great formality. Diego Ufano, Governor of Antwerp, describes the procedure:

"The piece having arrived at the battery and being provided with all needful materials, the gunner and his assistants take their places, and the drummer is to beat a roll. The gunner cleans the piece carefully with a dry rammer, and in pulling out the said rammer gives a dab or two to the mouth of the piece to remove any dirt adhering." (It was customary to make the sign of the cross at this point and invoke the intercession of St. Barbara). "Then he has his assistant hold the sack, valise, or box of powder,

and filling the charger level full, gives a slight movement with the other hand to remove any surplus, and then puts it into the gun as far as it will go. Which being done, he turns the charger so that the powder fills the breech and does not trail out on the ground, for when it takes fire there it is very annoying to the gunner." (And probably to the gentleman holding the sack). "After this he will take the rammer, and, putting it into the gun, gives two or three good punches to ram the powder well into the chamber, while his assistant holds a finger in the vent so that the powder does not leap forth. This done, he takes a second charge of powder and deposits it like the first; then puts in a wad of straw or rags which will be well packed in to gather up all the loose powder. This having been well seated with strong blows of the rammer, he sponges out the piece. Then the ball, well cleaned by his assistant, since there is danger to the gunner in balls to which sand or dirt adhere, is placed in the piece without forcing it till it touches gently on the wad, the gunner being careful not to hold himself in front of the gun, for it is silly to run danger without reason. Finally he will put in one more wad, and at another roll of drums the piece is ready to fire."

b. The maximum rate of fire of a field piece of this period was eight rounds per hour. Between shots the bore was swabbed with clear water or vinegar. After about 40 rounds the gun became so hot that it was unsafe to load, whereupon it was "refreshed" with an hours rest. The firing was seldom accurate, because of the irregular surface of the bore, the variation in size of the balls, and the imperfect powder. The approved procedure in adjusting was to have the first shot surely short, so as to afford a measurement of the error. The second shot should have been at a greater elevation, but also short. After the third round the gunner hoped to get hits. A celebrated artillerist of the time cautions the beginner against the desire to get hits on the first round, for, says he, "you will get overs and cannot estimate how much over."

c. A Flemish gunner of this period complains about having to use muzzle-heavy guns, making it necessary for him to hang a bucket of musket balls on the breech to get the required "preponderance." Artillerymen were thinking ahead of their crude materiel.

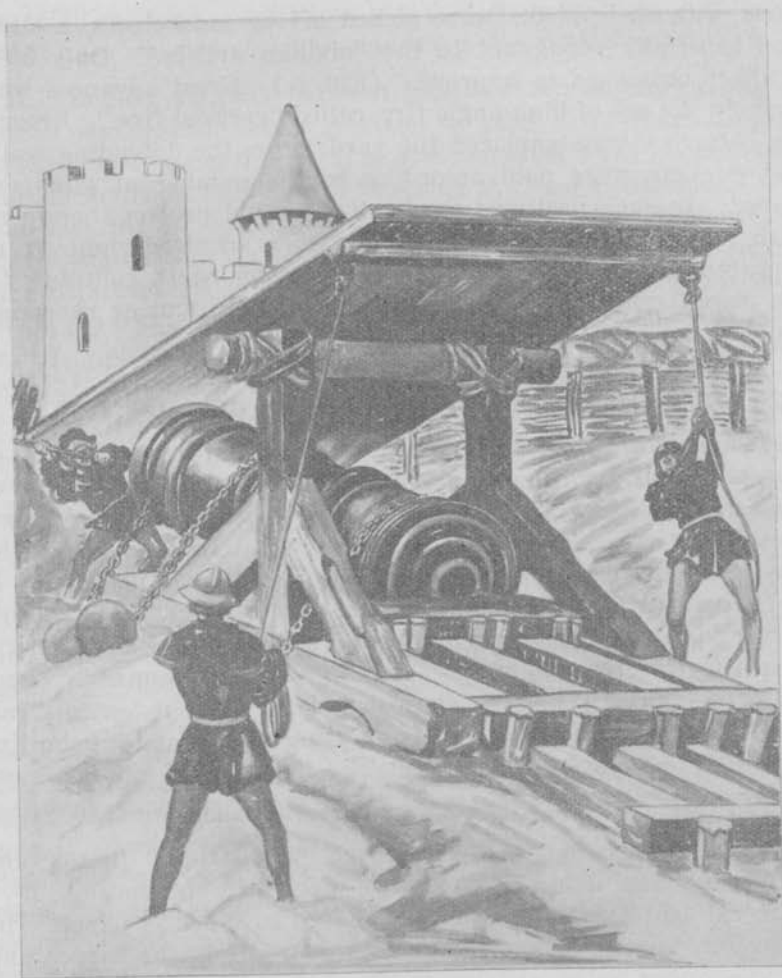


FIGURE 5.—Siege artillery of the 16th century.

19. **Decline of field artillery after the Battle of Pavia.**—Between the Battle of Pavia in 1525 and the Battle of Breitenfeld in 1631, field artillery and cavalry played a secondary role. The famous Spanish Square of heavy-armed pikemen and musketeers dominated the military picture. Because of their short ranges the unwieldy cannon had to be emplaced well forward, where they remained in either an advance or a retreat. Gunners who

stuck with their pieces were picked off by musketeers, a situation especially repugnant to the "civilian artists." Only siege artillery continued to improve. (FIG. 5.) Great advances were made in the use of high-angle fire, called "vertical fire." Breaching batteries were emplaced 100 yards from the defending walls, and gunners were paid according to the number of guns emplaced. In such positions the "artists" could protect themselves with earthworks or shields. Artillerymen acquired rights to all captured bells and metal implements, which were collected for the manufacture of more cannon and ammunition, or ransomed for cash.

20. Miscellaneous developments between 1500 and 1630.

a. Important experimentation went ahead in all parts of Europe. Spiral rifling was tried and abandoned. The use of explosive shell increased. Breechloaders were again tried; some were in active service in the British navy in 1545. In 1552, by a series of reforms in standardization of calibers, King Henry II of France put his country in the lead over the Germans. Niccolo Tartaglia, an Italian mathematician, published in 1562 the first scientific treatise on gunnery, and invented the gunner's quadrant. A German named Zimmerman in 1573 invented "hail shot," a form of case shot with a bursting charge and a primitive time fuze ignited by the propellant. The use of red-hot shot, employed successfully 200 years later, was first suggested.

b. Small arms had vastly improved by this time. In 1586 the musketeer was using a composite cartridge, consisting of a spherical lead bullet and a powder charge wrapped in paper. The paper was torn or bitten, the powder poured into the barrel, and the remaining bullet and paper rammed home. The same type of cartridge was used as late as the Crimean War in 1854.

c. In 1596, a certain Sebastian Halle suggested the idea of the modern time-and-percussion fuze, but the chemistry of his day was inadequate to cope with such advanced ideas. The fuze for many generations continued to remain a simple iron or wood tube filled with a slow-burning composition. However, it appears that some advanced ideas reached at least the pilot-model stage. Among the trophies of this period in the British War Office there

is a small-caliber wrought-iron gun that operates from a swiveled mount on a wheeled carriage, and has a distinctly modern look.

21. English artillery between 1500 and 1630.—The casting of cannon was introduced in England in 1521, fifty years after it appeared on the continent. The first English work on artillery, William Bourne's "The Art of Shooting in Great Ordnance," was published in 1587. In appraising his countrymen as artillerymen, Bourne stated that they were "hardie" but professionally behind the continental nations. They did understand the use of the gunners's quadrant and the inch rule for measuring elevation, but were completely baffled by the angle of site. Perhaps they specialized too much in naval warfare, where the angle of site was no problem. At any rate, they acquitted themselves quite well in 1588 in the defeat of the Spanish Armada, a victory due largely to superior English naval gunnery.

22. Summary of the early smoothbore period.—The first great revolution in artillery occurred about 1250, with the introduction of a new form of energy for the projection of missiles. Almost 400 years later cannon had developed from a primitive vase-like form, valuable chiefly for making noise, to the enormous bombards, which included the largest-caliber weapons ever constructed. Principles of construction had been tried and in many cases abandoned, only to reappear for successful development in later centuries. The science of ballistics had its origin during this period, and the first mobile gunpowder field artillery made its appearance in the cart guns of John Zizka. By 1600 caliber and range had been developed almost to the maximum possibilities of a muzzle-loading, smoothbore tube in which black powder was employed as a propellant. The emplaced cannon of 1600 could throw a solid iron ball or a charge of case shot almost as far as the gun of 1850. It was not in fire power, but in mobility, organization, and tactics that artillery was undeveloped. It was still largely a civilian monopoly. The reluctance of the industry to relinquish the perquisites of siege warfare had steered the development toward long, powerful, and heavy weapons, far too cumbersome for mobile operations. Towards the end of the period, across the Baltic Sea, changes were in the making that were destined to revolutionize field artillery design and the whole conduct of land warfare.

LATE SMOOTHBORE PERIOD (1630-1860)

23. **Reforms of Gustavus Adolphus.**—Gustavus Adolphus ascended the throne of Sweden in 1611 at the age of 17. Already a trained soldier and possessed of an unusually active and inventive mind, he set about to reform the army according to ideas of his own. Being a king, he was able to expedite the procedure. Faced with the prospect of a war against the Empire, he reasoned that the invincible formations of pikemen and musketeers, which had ruled the battlefields of Europe for a century, could only be broken up by cannon fire from pieces that were as mobile as the infantry itself. To meet these requirements he redesigned his artillery. In reducing weight, he had to do what every other designer of guns has had to do,—sacrifice fire power. He was convinced that the length and mass of the cannon of the day was far in excess of that needed, that pieces could be made shorter and lighter, and that a 12-pound projectile was heavy enough for field purposes. His first pilot model was not very successful. It consisted of a copper tube over which a series of iron rings was sweated, the whole being bound with rope, set in cement, and covered with leather. But eventually his young Chief of Artillery, Torstensson, produced a cast-iron 4-pounder and a 9-pounder demiculverin, both on wheels, that would function satisfactorily in firing, could be served by three men, and be maneuvered as desired. (FIG. 6). Other improvements equally important were introduced, such as combining the cannister or ball with the propellant in a single cartridge. With such ammunition, the light artillery of Gustavus Adolphus could be loaded and fired faster than a musket. He increased the proportion of cannon from one gun per 1000 infantry to six per 1000 and organized the arm tactically to provide both massed fire and accompanying weapons. His plans called for smashing the hostile heavy infantry formations with mobile artillery fire, simultaneously capturing or neutralizing the immobile enemy guns by a whirlwind cavalry charge. When all was in readiness, he ferried his army over to the continent and attacked the Imperial armies. The soundness of Gustavus' judgment was verified on the only true testing ground, the field of battle. At Breitenfeld in 1631, and at Lutzen a year later he smashed the Spanish Squares and changed the history of the world.

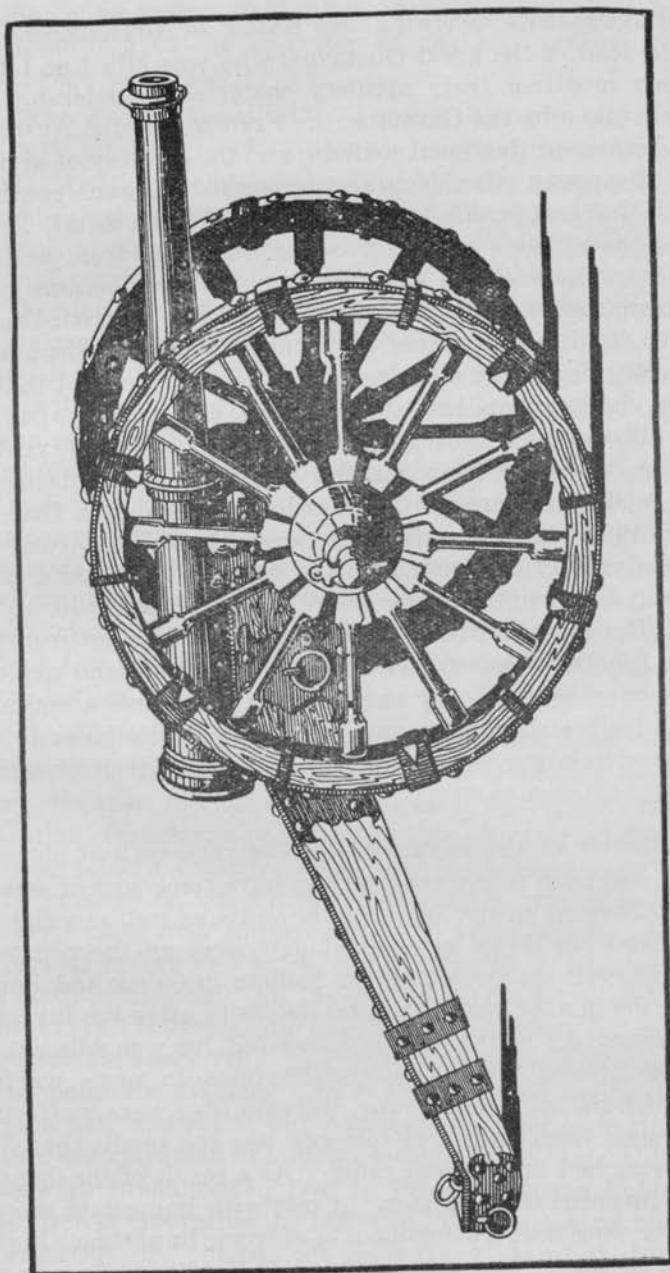


FIGURE 6.—Light artillery of Gustavus Adolphus.

24. Developments following the Battle of Breitenfeld.—Following the lead of the great Gustavus, who was killed at Lutzen, all nations modified their artillery materiel. Leadership was alternately taken by the Germans, the French, and the Austrians. Gunners became professional soldiers, and the mystery of artillery began to disappear. Cast-iron and wrought-iron guns continued to be made, but cast bronze became the favorite gun metal. Bronze withstood the stresses of firing better than cast iron, and was easier to manufacture than wrought iron. Calibers became standardized from one to six inches. The rate of fire increased to 100 rounds per day for light pieces, 30 rounds for heavy. The general method of service of the piece remained the same, except that the propelling charges were made up in wood, canvas, or paper cartridges. The charge was ignited through a priming vent by means of a linstock or slow match. Elevation was obtained by means of wedges or screws. The maximum range of a field gun was about 1600 yards, the effective range about 500 yards. The caliber was usually designated by the weight of the solid round shot fired. The length of the tubes varied between 15 and 20 calibers. The ammunition consisted of (1) solid cast-iron ball, (2) shell, a hollow iron sphere filled with powder and exploded by a slow-burning fuse, (3) case shot or cannister, a container filled with lead musket balls, and (4) grape shot, similar to cannister, but with larger and fewer balls, usually of iron, assembled in stands.

25. Invention of the howitzer.—In the very earliest siege operations it had been found necessary to have some sort of weapon capable of throwing projectiles over the walls, as well as a flat trajectory weapon to throw missiles at defenders on the ramparts. Thus the catapult supplemented the ballista in Greek and Roman times, and the mortar became a vital necessity after the invention of gunpowder. An additional need was felt for a mobile cannon to be used against temporary fortifications in open warfare, against which the solid shot, grape, and cannister were ineffective. Explosive shell fired from a mobile gun was too small; that fired from a mortar had insufficient range. As a result of the demand, the Dutch invented the howitzer. It met with immediate success, and has ever since been a component of extreme importance in field artillery armament. Because mortars and howitzers were chiefly

used for firing hollow projectiles, the caliber came to be designated according to the diameter of the bore, rather than the weight of the solid shot.

26. The wars of Louis XIV.—During the many sieges of King Louis XIV of France (1638-1715), mortars were greatly developed. Artillery schools were founded, and more books began to be published on the art of gunnery. There was a slow movement back to fire power at the expense of mobility, relieved by occasional return to lighter guns such as Marshal Turenne's in 1650. Frederick William of Prussia, the Great Elector, who was himself a trained artilleryman, effected tactical reforms. In 1672 a projectile was invented known as the "carcass," a hollow sphere pierced with vents and filled with incendiary matter. The carcass was retained by all armies as part of the normal ammunition for large howitzers and mortars until muzzle loaders went out of use. Smoke shell appeared in 1681. At that time artillery carriages were driven by wagoners on foot. In action the wagoners and animals moved off and subsequent maneuvering under fire was by manpower. By 1700, the pike, as the primary weapon for infantry, had been replaced by the flintlock musket and bayonet, and fire power rather than cold steel became the decisive factor in battles.

27. General developments between 1700 and 1800.—Between 1700 and 1800, including the period of Frederick's wars, field artillery became increasingly important by virtue of better organization, training, and discipline, but the role of the arm in battle was seldom decisive. Artillery again lagged behind the infantry in mobility, nor did improvements in cannon and ammunition keep pace with improvements in small arms. As in all other periods before and since, artillery found its greatest utility in stabilized situations. An innovation of Frederick William of Prussia (1713-1740) was to assemble all cannon for combined service practice every year. In France and Austria attention was given to mountain artillery. In 1740 Maritz of Switzerland introduced a new method of gun construction, that of boring tubes from solid metal instead of hollow casting. Important ballistic discoveries were announced in 1742 by the Englishman Robins. He was the first to determine the effect of "drag" or wind resistance on a projectile. He pointed out the advantages of the elongated

form of projectile, said that the center of gravity should be near the front, and advocated the rifling of cannon. Between 1744 and 1776 reforms were made in Austrian artillery by Prince Liechtenstein. He seems to have been the pioneer in establishing a separate artillery corps with an independent supply and transport. As a result of this reorganization, as well as his improvements in gunpowder and mobility, Austrian artillery was made the best in Europe. By 1750 siege guns were being mounted on mobile carriages. Land artillery had become definitely classified as field, siege, and fortress artillery.

28. Artillery of Frederick The Great.—Frederick II, the Great, of Prussia (1740-1786) realized the shortcomings of field artillery in mobility. In an endeavor to correct this, he introduced horse artillery and prescribed an elaborate system of maneuvers limbered. Firing characteristics were not much improved. In Frederick's time many of the ancient forms were still observed; gunners enjoyed special privileges, such as priority of service in the mess line. However, Frederick made the most of the short ranges of his weapons, as is evidenced by the following quotation from his regulations for the 3- and 6-pounder guns, which were habitually attached to the infantry:

"The guns to march in battle ahead of the infantry. At 500 paces from the enemy the gunners are to dismount and advance on foot, pushing their guns before them. An incessant fire is to be kept up while advancing, the last 300 paces with grape shot. Firing with grape is to be continued at closest range until the infantry catches up, passes through the artillery line, and storms the enemy's position."

Frederick used between two and five guns per 1000 men. For the attack of field fortifications he employed a large proportion of howitzers. It can be said of his artillery that, in spite of improvements in the direction of mobility, it was on the whole more distinguished for fire power than maneuverability.

29. Small arms prior to 1800.—Rifled small arms were being used on the continent, but the ammunition fired was no different from that used in smoothbore muskets. The greatest development occurred in the American Colonies, where the famous Kentucky Rifle was reaching its perfection. This rifle had been gradually

developed by Swiss and German settlers who came to Pennsylvania in 1683. They had brought with them the heavy Central European rifle of 1-inch caliber, in which the lead ball, larger than the bore, was forced into the rifling by hammering with a wooden mallet on an iron ramrod. Progressively the caliber was reduced and the barrel lengthened. To facilitate ramming, a lubricated patch was placed around the bullet. The Kentucky Rifle was more accurate than the standard military musket of the period, a .75-inch smoothbore.

30. British artillery prior to 1800.

a. British materiel of this period enjoyed a good reputation, being distinguished by lightness, elegance, and the superior quality of the metal and equipment. The calibers included 3-, 6-, 12-, and 24-pounders. Pieces were organized in heavy or light "brigades" of from four to six weapons each. Field guns were drawn by four horses, the two leaders being ridden by artillerymen. Each piece was supplied 100 rounds of solid shot and 30 rounds of grape. The first appearance of American field artillery in battle dates from 1745, when the British and Colonial forces captured Louisburg from the French. Serving with the British Royal Artillery was a detachment of Massachusetts militia, members of the Ancient and Honorable Artillery Company of Boston, organized in 1637.

b. In 1780, the British army in India became acquainted with rockets, which had been used by oriental nations a long time. At first they were employed only for incendiary purposes, but it was hoped to utilize them in lieu of mountain artillery. Sir William Congreve, whose name is prominent in the British artillery of his time because of many improvements he made, was enthusiastic about the rocket and expected to develop it to the point where it would replace all artillery. Results along this line did not materialize as he predicted, but the experiments with rocket projectiles contributed to the development of modern shrapnel. The British continued to use rockets until well into the 19th Century. The American army in Mexico in 1847 included a rocket battery. Rockets seem to have had considerable demoralizing effect upon untrained troops. It is said that their use by the British against the raw American levies at Bladensburg in 1814 contributed to the disgraceful rout of the latter and the capture of Washington.

c. In 1784, Lt. Henry Shrapnel, later a General in the British Army, invented a successful spherical case shot with a time fuze. Although earlier attempts had been made to produce a projectile of this kind, as Zimmerman's in 1573, Shrapnel's invention was the first to produce an air-bursting case shot which imparted directional velocity to the contained bullets. The new projectile came into use about 1800, but was not known by its inventor's name until 1852.

31. Gribeauval's reforms.—The year 1765 marks the beginning of a great reform in French artillery, instituted by Gribeauval. He obtained his original ideas from the Austrians, with whom he had served in the wars against Frederick, but he contributed many ideas of his own. His changes revolutionized artillery in every department and vitally influenced developments in other countries, including the United States. Gribeauval's reforms were at first resisted, but when he became Inspector General of French artillery in 1776 he accomplished his aims. He determined the exact propelling charges and the proper relation between charges and weights of projectiles. He determined the proper thickness for the wall of the tube in proportion to the firing strains, enabling him to shorten the tube and lighten both guns and carriages. He made soldiers out of the drivers, and arranged the horses in pairs instead of tandem. He reduced the number of calibers and provided interchangeability of parts. He introduced the caisson. For the first time in history, weapons larger than an 8-pounder had sufficient mobility to accompany an army in the field. Gribeauval's reformed artillery came into action at a gallop. The pieces would approach slowly under cover to within about 1200 yards of the enemy, just out of range; then the cannoners would mount, the sections would gallop up to 800 yards, unlimber, and smother hostile batteries of greater caliber by an overpowering volume of fire. The range of his guns was 1400 to 1600 yards. The Gribeauval-type materiel, with slight modifications, remained until 1825, and was used in its essential form by Napoleon in all his wars. (FIG. 7).

32. American Revolutionary War. (Fig. 8).

a. American artillery in the Revolutionary War (1775-1783) was an accumulation of guns, mortars, and howitzers of every sort, mostly of pre-Gribeauval type. About 13 different calibers were

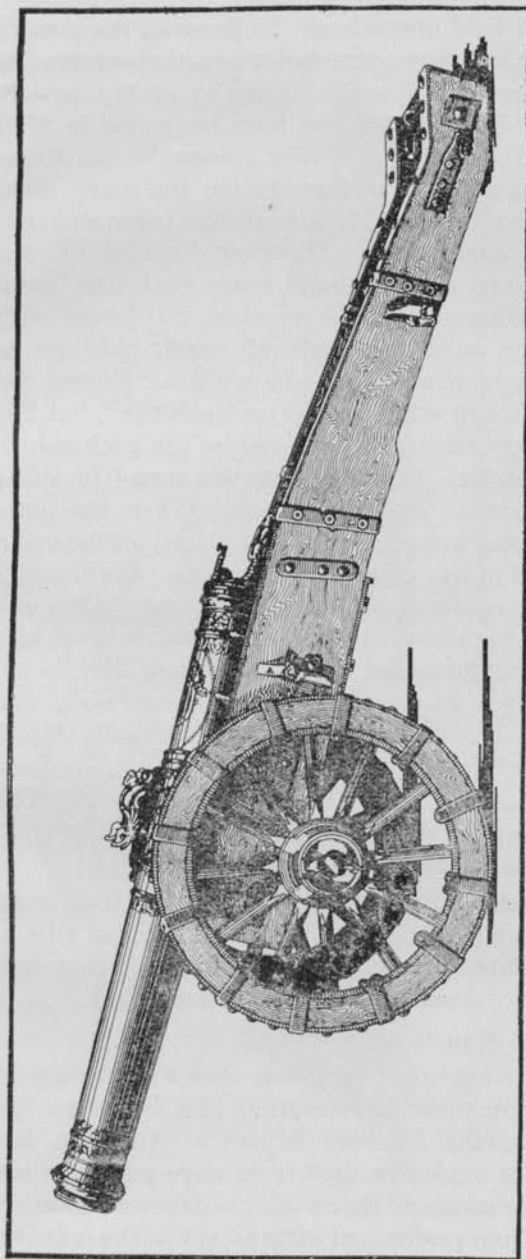


FIGURE 7.—Gribeauval 12-pounder gun.

actually used in field operations. In general, the materiel, organization, and tactics were modeled after that of the British and followed the standard English authority of the period, Muller's *Treatise on Artillery*, which had been published in 1757 and was republished in Philadelphia in 1779. Some bronze French cannon without carriages were received during the war. Brass casting was undeveloped in the Colonies at the beginning of the war; copper and tin were scarce. However, by 1775 the foundries of Philadelphia were casting both brass and iron cannon. The typical gun carriage was made of wood, reinforced with wrought iron. Even the axle was made of wood. Lighter guns were elevated by screws, heavier guns by wedges. Horses were hitched in single file. There was no chest on the limber, but 24 rounds of ammunition were carried in "side boxes" on each side of the trail in rear of the axles. Cartridges were carried in an upper compartment, projectiles in a lower one. When the piece was "in battery" the boxes were removed and placed on the ground. Additional ammunition was transported in carts. Civilian drivers were hired. Oxen were often used instead of horses. On the battlefield, the guns were maneuvered by drag ropes manned by the "matrosses", as the cannoneers were then called. Mobile guns ranged from 3-pounders to 24-pounders, howitzers were 5½- and 8-inches, all of bronze. The lighter guns were habitually attached to infantry brigades, the howitzers occasionally. A few cast-iron siege guns of 18-, 24-, and 32-pounder caliber were used. The standard ammunition for guns was solid shot, grape, and case shot; for howitzers and mortars, shell and carcasses.

b. The standard infantry musket used by both forces was the "Brown Bess" smoothbore, but the long-barrelled rifle used by the frontiersmen showed to such advantage that it hastened the adoption of rifling for small arms by the entire world.

33. Wars of Napoleon.

a. In 1788, Napoleon Bonaparte, then a lieutenant of artillery, was the junior member and recorder of a board convened by the Commandant of the Artillery School at Auxonne, to study the effects of fire of explosive shell from siege guns and mortars. In 1792, at the beginning of the revolutionary wars, French artillery was divorced from permanent attachment to the infantry, and like the Austrian artillery, became a separate arm. Horse artillery,

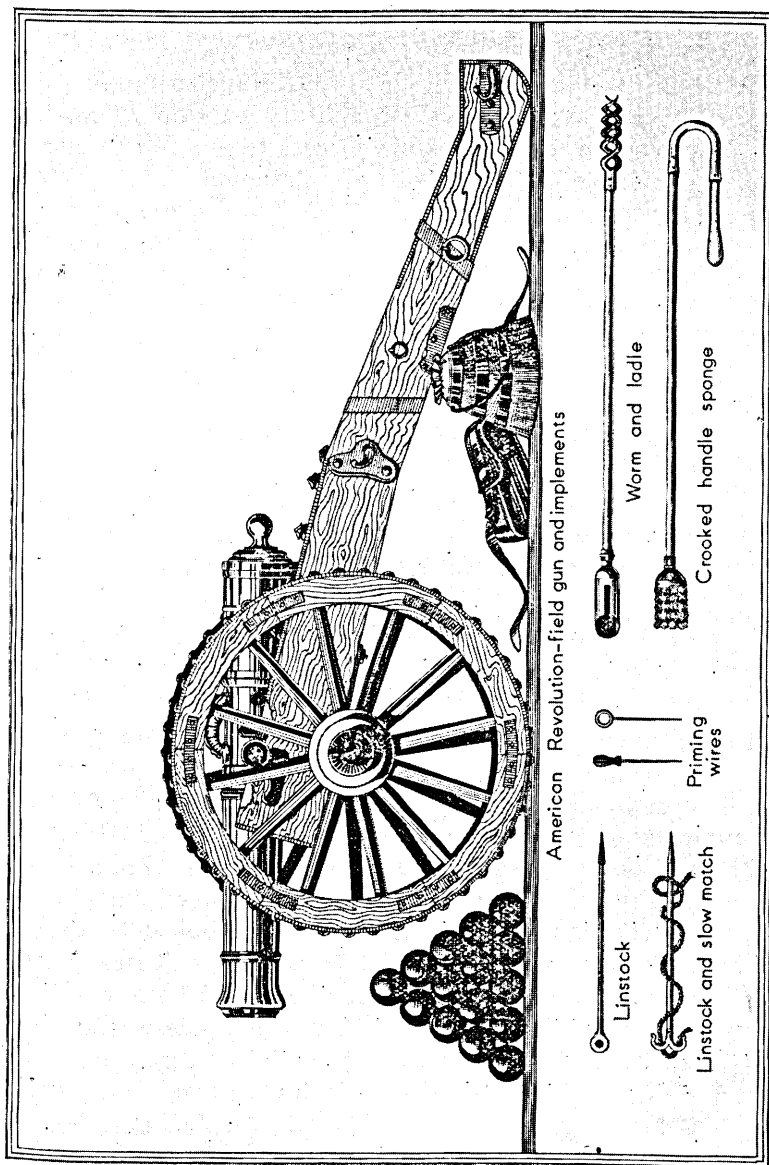


FIGURE 8.—6-pounder field gun used by American Revolutionary Forces (1775-1783).

previously used by Charles XII of Sweden and Frederick the Great, was adopted and because of its mobility became the most popular type in the Revolutionary armies.

b. At Jena and Auerstaedt in 1806, Napoleon Bonaparte established himself as the greatest military captain of modern times. Napoleon owed much of his success to a masterly use of the arm in which he had been trained. Although forced by circumstances to use guns and carriages of the Gribeauval type, which were becoming obsolescent, he effected numerous improvements in simplification, organization, and particularly in tactical handling. Napoleon observed that his subordinate commanders made no distinction in the tactical use of 4-pounders and 8-pounders. Accordingly he abolished both, substituting therefor a 6-pounder. He organized his artillery into three classes, divisional, corps, and reserve. His batteries contained six pieces. Gun teams consisted of six horses, caisson teams of four; drivers rode the off horses. His field pieces were 6-, 9-, and 12-pounder guns, and 5½-inch howitzers, all bronze. There was one howitzer for each five guns. Concerning the role of artillery in his campaigns, Napoleon wrote:

"It is the artillery of my Guard (reserve) which decides most of my battles, because having it always in hand I can use it when and where necessary."

c. Under Napoleon, field artillery again became the predominant arm in fire power. The preparations he employed were not of the slow methodical sort. His guns went up rapidly to the closest range, and by actually annihilating a portion of the enemy line with case shot, covered the assault so effectively that columns of cavalry and infantry reached the gap without striking a blow. In many respects his use of artillery resembled that of Frederick, with improvements in mobility. In the matter of fire power, ammunition, and service of the piece there had been but little advancement; indeed the artillery of Napoleon's time was so similar to that of Gustavus Adolphus that the latter's gunners could have served the great Corsican's batteries without much difficulty.

d. Shrapnel's spherical case shot was first used by the British against the French in the Peninsula campaign in 1808. Congreve's rocket projectile, filled with slugs and fired from cannon, was the

type of shrapnel used by the British at Waterloo in 1814. British artillery had been steadily improving, and as a result of the victory at Waterloo it acquired a high reputation, especially as to maneuverability. British carriages had a superior type of trail, and their limbers mounted an ammunition chest.

34. Developments in small arms after 1800.

a. Fulminate of mercury was isolated in 1800, an event which soon led to the introduction of percussion caps for muskets and friction primers for cannon, and eventually led to the development of modern fuzes.

b. Prior to about 1800 the hand grenade had been a most important infantry weapon, and grenadier companies held the post of honor in regiments. With the improvements in small arms the grenade was considered obsolete, and grenadier units disappeared as regularly organized formations. However, it will be seen the grenade has a habit of reappearing whenever fighting gets to close quarters.

c. In 1811, a French gunsmith named Pauly presented to Napoleon a breech-loading rifle, firing an elongated bullet. Pauly's remarkable weapon, of 16-mm. caliber, had a twisted rifling and fired cartridges with an assembled primer of potassium chlorate exploded by a hammer. It was basically the same weapon as the needle gun given to the Prussians by Dreyse 30 years later, concerning which gun Dreyse got his ideas while working for Pauly in Paris. It is interesting to conjecture how the history of the world might have been changed had Napoleon been able to use this weapon.

d. In 1811, Capt. John H. Hall was granted a patent for the first breech-loading small arms in the United States. From 1817 to 1841 many thousands of these rifles were made at the Harpers Ferry Arsenal, where Hall was in charge. Hall's weapon was of .54-inch caliber. The breech consisted of a block pivoted at the rear, which carried the flash pan and hammer, and into which the cartridge was pushed from the front. The block was then depressed and held by a spring catch. In 1832 Hall applied the percussion-lock principle to his rifles and carbines. The use of percussion caps instead of flintlock igniting devices was made possible by the discovery of mercury fulminate and the inventions

of Forsythe in Scotland and Shaw in Philadelphia, but the Springfield Arsenal did not adopt Shaw's cap until 1842, nor did it begin to manufacture rifles instead of smoothbore muskets until 1855. By 1857, when the Sharp's breech-loading rifle appeared, infantry small arms were nearly all rifled, although none of the government models except Hall's were breechloaders. The Springfield rifle of 1855 fired an elongated bullet of the Minie type, which had a conical cavity at the base. The caliber was .58-inch. The Colt six-shooter revolver was perfected as early as 1835.

e. In 1838, the German Dreyse, who had collaborated with Pauly in Paris between 1808 and 1814, invented a breech-loading rifle called the "needle gun." It was adopted by the Prussian army in 1848. It fired an elongated bullet, 14-mm. in caliber, weighing 31 grams, propelled by a cylindrical paper charge of powder ignited by a percussion cap on the *interior* of the bore, the cap being fired by a needle-like pin. The weapon had an effective range of 700 yards. For the first time the infantryman could load his piece from the prone position, a circumstance which was to have a profound effect not only upon infantry tactics, but upon artillery materiel and ammunition as well. The Prussians used this rifle for 25 years. It spelled the eventual doom of case shot and cannister, and finally of shrapnel.

f. Other European nations were using rifled small arms by this time, but the lead bullet was forced into the rifling from the muzzle end. In 1848, Captain Minie of the French Army devised a rifle firing an oval-type bullet with a cupped depression at the base. The pressure of the powder expanded the rear walls of the bullet against the bore and made a better seal than solid types. Most of the American Civil War rifles fired modifications of this lead slug, called by our grandfathers the "Minnie ball." The Minie rifle had a maximum range of 1000 yards, and was deadly at 500 yards, whereas the old "Brown Bess" smoothbore musket was ineffective over 200 yards.

35. American artillery developments between 1790 and 1845.

a. In the United States in 1793, brass cannon were being cast at the government foundry in Springfield, Massachusetts. American artillery was profoundly influenced by the translation of de Scheel's treatise on the Gribeauval system of artillery. This

treatise was disseminated to the American army in 1800. In 1809, Lt. Col. de Tousard, a naturalized Frenchman and a veteran of the American Revolution, published at the request of President Washington the first original scientific work on artillery produced in the United States. The same year the American artillery adopted the Gribeauval system of artillery carriages in toto, just about the time it was becoming obsolete. Gribeauval's system of gun calibers was never adopted. Two French guns with complete equipment, which had been acquired at New Orleans, were sent to Washington as models.

b. An interesting development occurred in the American artillery between 1801 and 1836. Bronze as a gun metal was abandoned in favor of cast iron for all calibers. The substitution was pushed by the growing iron industry and prevailed in spite of the preponderance of military opinion. The American forces in the War of 1812 fought largely with iron 6-pounders, and in the regulations of 1816 cast iron alone appears as a gun metal. After this strange interlude of 35 years, bronze was readopted in 1836 for mobile guns and howitzers, and remained supreme until the introduction of rifled cannon. Only the larger calibers of siege and seacoast guns continued to be made of cast iron. Like the bombards of medieval times, the latter grew in size and weight, culminating in the gigantic Columbiads.

c. The organization of the Ordnance Department of the United States Army merits a brief digression at this point. During the Revolutionary War and until 1815 there had been no separate Ordnance Department. The functions of that service were performed by officers detailed from other branches, particularly the artillery. From 1815 to 1821 the Ordnance was organized as an independent branch. Between 1821 and 1832 it was again merged with the artillery. The merging system proved to be unsatisfactory because artillery officers were permitted to serve only one year at a time on Ordnance duty, after which they went back to troops. In 1832 the Ordnance became independent again and has remained so.

d. Several distinguished boards of officers were appointed to modernize American artillery. The Macomb Board of 1835 unanimously recommended a return to the French system of bronze construction for field cannon. Cast-iron field pieces invariably

burst first when tested in competition with bronze guns of equal weight. For guns in position, where weight was not a prime consideration, cast iron was retained. The new French carriage construction was adopted, which, with slight modifications, remained the standard type through the Civil War. For use against the Indians, a 12-pounder mountain howitzer was added to the artillery. For fixed artillery, wooden carriages came back into favor, replacing the cast-iron mounts which had been standard for 20 years. In 1845, Lt. Rodman began his investigation of the interior-cooling (hollow cast) principle of heavy gun construction.

36. European developments to include the Crimean War.

a. The French abandoned the Gribeauval system in 1829. Henceforth French cannoneers of light batteries rode the caissons and limbers instead of walking. The Dispart sight, a device similar in principle to the sights used on modern infantry rifles and machine guns, was applied to cannon. In 1833, Thiery produced in France a built-up gun, consisting of a cast-iron tube cased in longitudinal wrought-iron bars, reinforced by wrought-iron hoops shrunk on. In many respects it was a return to the construction of Mons Meg.

b. Important experiments in ballistics were conducted by the French at Metz, continuing the work of Robins (1742) and Hutton (1755-1788). Captain Piobert lectured that the ideal projectile was tear-drop in shape, with the largest diameter two-fifths of the distance from the front. Military men had long known that the spherical type of projectile was not ballistically efficient. The round shot fired from the smoothbore cannon lost velocity rapidly—at 2000-yards range the remaining velocity was about one-third the muzzle velocity. Experiments to impart rotation to an elongated type of projectile at last began to bear fruit. Cavelli, in Italy in 1845, and Wahrendorff, in Germany in 1846, produced the first workable breech-loading rifled iron cannon. These were followed shortly by other models in other countries. The Cavelli gun had two grooves which engaged lugs on the projectile. The Lancaster gun attempted rotation by means of an elliptical bore; the Whitworth gun, somewhat more successfully, with a hexagonal bore and projectile. (FIG. 9). But in spite of these experimental models, the ordnance in actual service

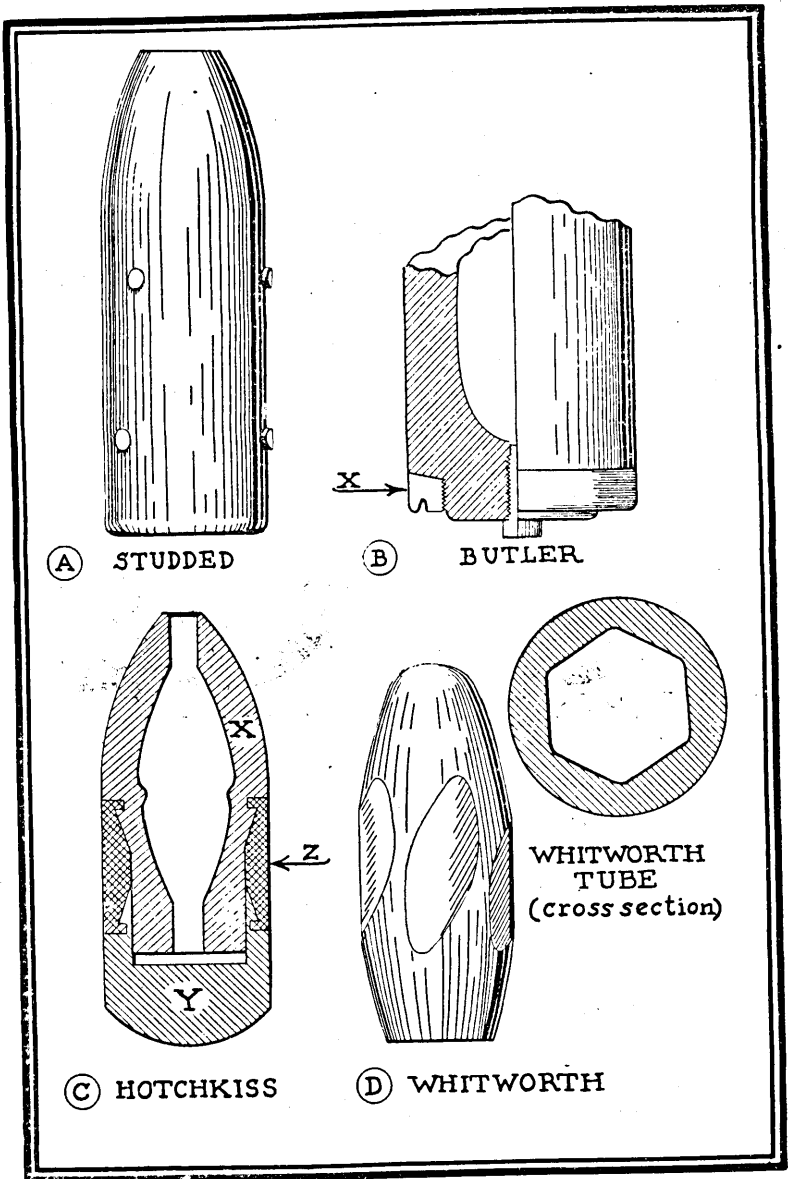


FIGURE 9.—Means of obtaining rotation with early projectiles.

in all the armies of the world was of the conventional smoothbore pattern.

c. Discoveries in chemistry were made which led in course of time to a tremendous revolution in explosives. In 1845 Professor Schonbein produced gun cotton, and a year later Professor Sobrero discovered nitroglycerine. With respect to these discoveries, as well as to the experimental guns described above, it must be remembered that wars are not fought with pilot models, but with the quantity stocks on hand, in the use of which the personnel have been trained.

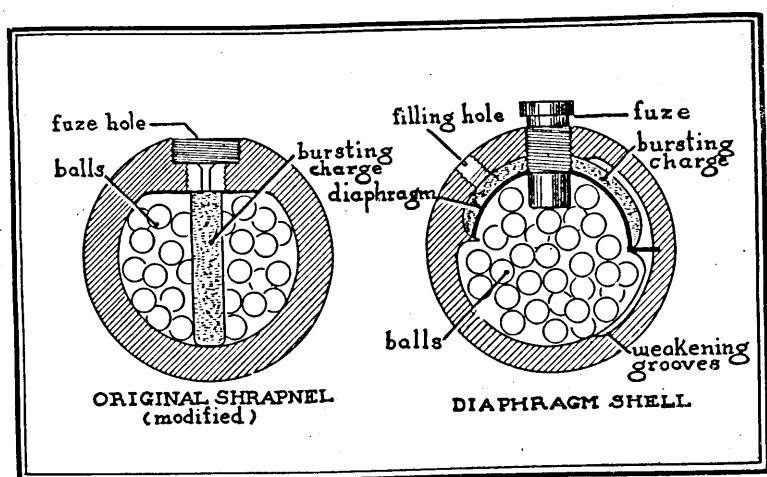


FIGURE 10.—Spherical case shot (early form of shrapnel).

d. In the Crimean War (1854-1856), fought by the English, French, and Turks against the Russians, smoothbore cannon were used exclusively. Spherical case shot was the ammunition principally employed (FIG. 10). Artillery and grenades caused 43% of the casualties. Red-hot shot was discarded for "Martin's shell" filled with molten iron.

e. Experiments with rifling in cannon now began in earnest in Europe. Armstrong in England and Krupp in Germany produced models of breech-loading rifled guns. The Armstrong piece used coils of wrought iron to give strength; the Krupp design was a monobloc gun depending for strength on its superior crucible-steel material. The Krupp gun had an especially suc-

cessful breech mechanism. A model of a built-up gun, called the Chambers gun, appeared in the United States in 1849.

37. American artillery of the Mexican War period.

a. (FIG. 11). A complete picture of the American artillery of the Mexican War period may be found in the official report of a board of Ordnance officers prepared by Captain Alfred Mordecai in 1849. This board had been appointed by the Secretary of War in 1839 to "devise and arrange a complete system of artillery and supplies." After 10 years of research, the board submitted its report in the form of a bound volume supplemented by a book of large hand-colored engravings. It shows that the ordnance in the land service of the United States in 1848 was classified as field (including mountain), siege and garrison, and seacoast. All cannon were muzzle-loading smoothbores. The field pieces, except mortars, were made of bronze; most of the heavier weapons were cast iron. The bore of a gun was of uniform diameter the full length; that of a mortar or howitzer was narrowed at the rear to form a powder chamber. The calibers and weights of tubes of the field pieces were as follows:

Guns (all bronze):

6-pounder (caliber 3.5 inches), weight 884 pounds.

12-pounder (caliber 4.4 inches), weight 1757 pounds.

Howitzers (all bronze):

12-pounder, mtn, (caliber 4.4 inches), weight 220 pounds.

12-pounder, fld, (caliber 4.4 inches), weight 788 pounds.

24-pounder, (caliber 5.6 inches), weight 1318 pounds.

32-pounder, (caliber 6.2 inches) weight 1890 pounds.

Mortars (cast iron):

8-inch, weight 930 pounds.

10-inch, weight 1852 pounds.

b. The siege, garrison, and seacoast pieces were of 16 types, ranging from a 12-pounder (4.4 inch) gun weighing 3590 pounds to a giant Columbiad of 10-inch caliber weighing 15,260 pounds. (FIG. 12). The proportion of howitzers and mortars was large.

c. The carriages of field pieces were made of selected oak wood, reinforced with wrought iron. Carriages of some types were interchangeable, such as the 6-pounder gun with the 12-pounder howitzer, the 12-pounder gun with the 32-pounder howitzer, and the 24-pounder gun with the 8-inch howitzer. The axles

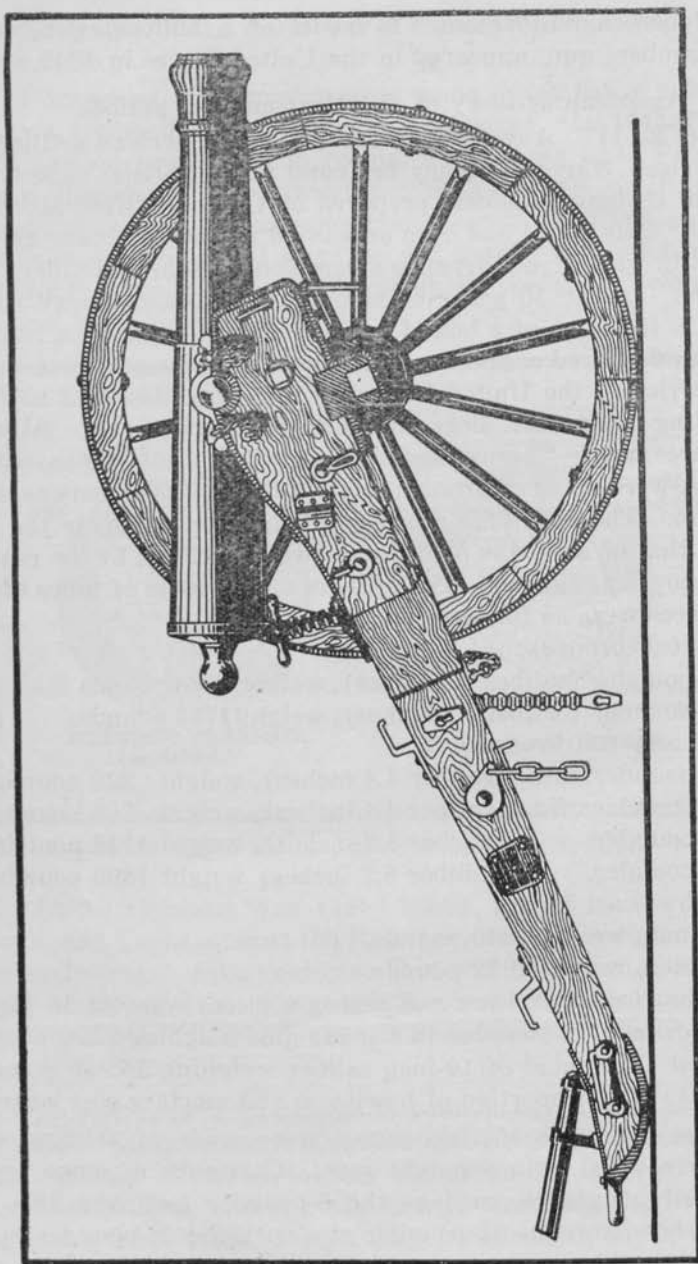


FIGURE 11.—6-pounder field gun, Mexican War (1847).

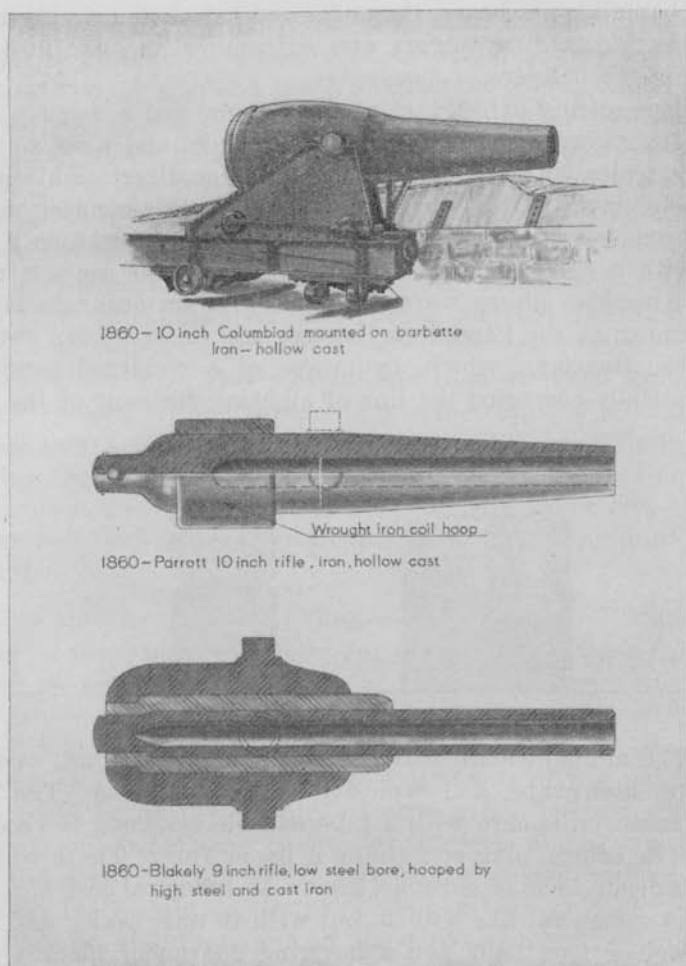


FIGURE 12.—American Columbiads and contemporary types.

were of wrought iron; wheels were wooden with an iron rim shrunk on. Caissons and limber chests were of wood, reinforced with iron. The battery vehicles consisted of pieces, caissons, forge wagon, and battery wagon, all with interchangeable limbers. The tools, accessories, and spare parts listed for a battery seem fully as numerous as those of today. The list bears many familiar items, but also many which have since disappeared from our SNL's such as powder ladles, linstocks, port-fire stocks,

budge barrels, pass boxes, tongs for red-hot shot, priming horns, dredging boxes, fuze augers and extractors, powder measures, and gunner's calipers.

d. For setting off elevations the gunner had a wooden quadrant constructed on the plumb-bob principle, and a set of brass tangent scales with stepped notches used for direct sighting over the line of metal. It is worth remarking, in this connection, that the Prussian artillery as early as 1843 was using a gunner's quadrant with a spirit level quite similar to the one we use today. Some American pieces were equipped with an accurate tangent scale known as the Pendulum Hausse, said to have been obtained from the Russians, which, by means of a weighted pendulum, automatically corrected the line of sighting for cant of the trunnions.

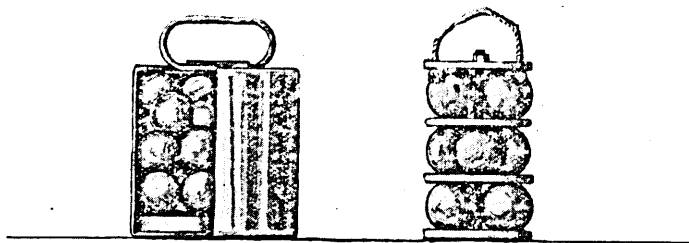


FIGURE 13.—Case shot or cannister, and grape.

e. The ammunition consisted of solid cast-iron shot, cast-iron cannister and grape, and explosive shell. (FIG. 13.) The latter was a cast-iron sphere with a tapered hole designed to receive a wooden or bronze plug containing a paper fuze. There was also in use a crude form of shrapnel known as spherical case shot, constructed somewhat like a shell, but with thinner walls, and filled with lead or iron balls and a bursting charge of black powder (FIG. 10). The incendiary mortar shell known as the "carcass" was also issued. The ammunition for all field guns and the 12-pounder howitzer was known as "fixed." The projectile and powder bag were attached to opposite sides of a thick disk of wood called a sabot, permitting the handling and loading of the complete round as a unit cartridge. In transportation, cartridges were protected by cylinders and caps of strong paper. Cannisters were made of tin, with an iron plate at the bottom, and were nailed directly to the sabots. Fuzes were inserted at the time of loading the piece.

f. The mountain gun of 1848 was a 12-pounder bronze howitzer, transportable by either pack or draft. When packed, one horse carried the gun and shaft, another the carriage, and a third carried two chests of ammunition. Additional animals were needed for repair tools and blacksmith's equipment. When used in draft, a single horse pulled the piece. The ammunition used was similar to that for the 12-pounder field gun with a smaller powder charge.

g. Experiments with rifling were still considered in their infancy, for the United States in 1857 adopted the 12-pounder (4.62-inch) Napoleon gun-howitzer, which was a bronze smooth-bore muzzleloader. This weapon had been designed by the Emperor Napoleon III of France. It was the result of a demand for greater power in a field piece without additional weight. Considering the relatively ineffective ammunition of those days, the decision was a wise one, for this weapon proved to be very valuable in the Civil War and remained standard in the army until as late as 1881.

38. Experiments with rifling.—In 1859 the French tried rifling in their bronze cannon but gave it up because the metal eroded too quickly. By this time forward-looking artillerymen were convinced that the cannon of the future would be rifled. The United States, like most nations, had large stocks of smoothbore weapons on hand. The Ordnance Board was of the opinion that these could be converted into effective rifled cannon simply by rifling them, "which can be done at the forts and arsenals where they now are." It was stated that the conversion would result in doubling the weight of the projectiles, giving greater accuracy, effectiveness, and range, and all this without an increase in powder charge. Accordingly, in 1860, it was recommended that 50 percent of the artillery weapons be rifled. At the same time it was recommended that all large calibers of cast-iron cannon be cast on Captain Rodman's principle of interior cooling, which had proved to be sound. This principle effected in a measure the same results that are obtained today by means of the auto-frettage or cold-working method. The Board also pressed the adoption of wrought-iron carriages for seacoast guns, thus discarding wooden carriages for the second time. The conversion of old smoothbores to rifles merely by giving them lands and grooves resulted in

utter failure, as the guns could not withstand the increased pressures resulting from increasing the weight of the projectiles. In 1857 the United States rifled all its old smoothbore muskets.

39. Summary of the late smoothbore period.—In this period, lasting a little over 200 years, the smoothbore, muzzle-loading cannon reached the zenith of its development. So far as fire power and range were concerned, there was no appreciable advance over the guns of 1600, but, beginning with Gustavus Adolphus, revolutionary improvements were made in mobility, organization, and tactical handling, enabling a more effective use of the available power. As a result, field artillery under Gustavus Adolphus, and again under Napoleon, played a decisive role on the battlefield. The period saw the passing of the art of artillerist from a purely civilian industry to an independent arm of the military profession. It saw gunnery and ballistics established on a scientific basis. Toward the close of the period certain chemical and physical discoveries enabled improvements to be made on small arms which again placed field artillery at a disadvantage and made imperative new and greater developments in cannon and ammunition.

TRANSITIONAL PERIOD (1860-1897)

40. Predominance of small-arms fire.—The early part of the period was marked by a great development in infantry small arms, paralleling the conditions which prevailed between 1525 and 1631. The net result was a tremendous strengthening of the defense in combat. The artillery was again dethroned from its preeminent place in fire power, to which it had been elevated by the great Bonaparte. The tactics of Napoleon's time could no longer be employed. A preparation by massed artillery at close ranges became suicidal. The guns were forced to stand off at a greater distance, at which range their primitive ammunition was relatively ineffective. The defending infantry and artillery were therefore left practically intact to pour a devastating rifle and cannister fire at point-blank range into the assaulting infantry. This was the reason for many bloody repulses in the American Civil War, such as at Fredericksburg, Gettysburg, and Cold Harbor.

41. American Civil War.

a. The opening of the American Civil War (1861-1865) found artillery materiel largely of the smoothbore type. The first

rifled weapons appeared when the Union War Department purchased 300 wrought-iron rifled field guns of 3-inch caliber, commonly known as 12-pounders. These new guns were not looked upon with favor by the service in general, but were nevertheless adopted, and became the standard Ordnance cannon during the war, although not the most numerous. At the same time, owing to pressure by the iron foundries and a few enthusiasts in the artillery, a quantity of cast-iron rifles, hooped with wrought iron at the breech, were manufactured. These weapons, mostly of larger caliber for siege and garrison purposes, were known as Parrott guns. (FIGS. 12 and 14.) One foundry made some 1700 during the course of the war. Parrott guns of 10-, 20-, and 30-pounder caliber were found in the Army of the Potomac as early as 1861, but the bulk of the artillery materiel in use by the Union forces in that year consisted of the following types:

- 12-pounder (3.0") rifle (wrought iron)
- 6-pounder (3.5") smoothbore gun (bronze)
- 12-pounder (4.5") smoothbore gun (bronze)
- 12-pounder (4.6") smoothbore gun-howitzer, Napoleon (bronze)
- 12-pounder (4.5") smoothbore mountain howitzer (bronze)
- 12-pounder (4.5") smoothbore howitzer (bronze)
- 24-pounder (5.6") smoothbore howitzer (bronze)
- 32-pounder (6.2") smoothbore howitzer (bronze).

b. Siege and garrison cannon included various types and calibers from a 4.5-inch rifled gun of cast iron to a bronze 8-inch howitzer and a bronze 10-inch mortar. Seacoast armament, all of cast iron, consisted of large-caliber smoothbore guns, mortars, and Columbiads, including a 15-inch Rodman gun, the most powerful weapon known in the world at that time.

c. The point-blank effective range of the 6- and 12-pounder smoothbore field guns was 600 to 700 yards, firing case shot (FIG. 13). Grape shot, the balls of which were larger, when fired from a 12-pounder gun could disable men at 880 yards. The maximum range of the 12-pounder Napoleon, firing solid shot, was 1566 yards; that of the 24-pounder howitzer was 2200 yards; that of the 6-inch howitzer about 2600 yards. To open a useful breech in a good stone wall required several hours of cool systematic firing at very short ranges. The rifled guns had a greater

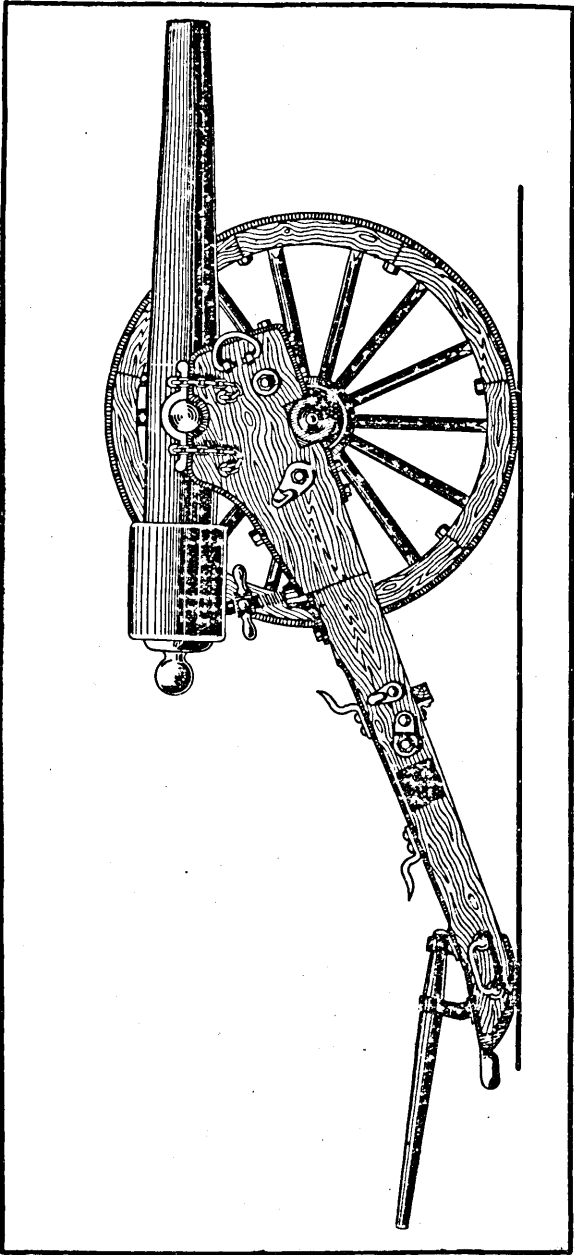


FIGURE 14.—3-inch Parrott rifled gun, Civil War (1861-1865).

range; the 3-inch muzzle-loading rifle fired a 10-pound projectile to twice the range of the Napoleon. However, because of the smaller caliber, it was not as effective at short ranges, and the poor ammunition and direct-laying methods of those days deprived its greater range of much of its value.

d. As to organization, an armament committee composed of General Barry, Colonel Hunt, and Captain Rodman, in 1861 recommended that light batteries be equipped with eight pieces and horse batteries with six, all pieces to be of the same caliber and type. Light batteries were to be equipped with either 12-pounder Napoleons or 3-inch rifles; horse artillery was to have 3-inch rifles exclusively. Records of the war show that most batteries contained six pieces.

e. Confederate artillery was generally similar to that of the Union forces, except that the South employed a few breech-loaders obtained from Europe. The breech-loaders were not especially successful.

f. By 1863 the materiel was much the same except in quantity. A few more rifled types, such as the James rifles and the Wiard steel guns, had made their appearance, and there was a greater number of Parrott guns in evidence, but the preponderance of field pieces consisted of 6- and 12-pounder smoothbores. Stonewall Jackson, in his great turning movement at Chancellorsville, had about 80 guns, firing solid shot and cannister. It is reported that his first battery to be engaged in that action fired a solid shot which bounded down the center of a roadway and came to rest a mile distant, an account which verifies the drill-regulation ranges given above. At Gettysburg, the Union artillery had 67 batteries with 372 guns, 8000 men, and 7000 horses, an average of 21.5 men per gun.

g. The records of the Civil War, when studied to determine the relative merits of rifled weapons and smoothbores, indicate that under the conditions prevailing, the smoothbores gave generally the best results. The smoothbores of 6- and 12-pounder caliber fired a heavier charge of shot than the smaller-caliber rifle, and in the broken, heavily wooded country where firing with direct laying had to be done at short range, were generally more effective. Birkhimer, writing in 1884, says: "The 3-inch wrought-iron rifle

of 1861 was pronounced too light, in weight of metal thrown, by those who used it extensively during the Civil War."

h. In heavier ordnance, although a few rifled guns were constructed during the war, the smoothbores remained supreme, the only development being in size. In 1864 a Rodman gun was produced of 20-inch caliber which threw a shot weighing 1080 pounds.

i. A form of gas projectile called a "stink shell" was invented by a Confederate officer, but was not used because of its "inhumanity", and probably also because it was not considered valuable enough to offset its propaganda value to the enemy. Camouflage and cover were more extensively employed than is generally believed, and even rough methods of indirect laying were used in stabilized situations.

42. European developments between 1860 and 1870.

a. In 1862 Prof. Alfred Nobel started the manufacture of nitroglycerin explosives. In 1864 the British government, having tried breech-loading guns for some years, went back to muzzle-loaders, which they retained until 1880.

b. In 1866 occurred the short Austro-Prussian War. As in the American Civil War, a mixture of smoothbores and rifled guns was employed. Although the Austrian artillery appeared to better advantage, the Prussians won the war, largely because of the superiority of its infantry which was equipped with the famous needle gun. Prussian artillery learned much about its shortcomings in this war, and turned that knowledge to good account four years later.

c. By 1867 practicable time and percussion fuzes on modern principles had been introduced, and breech-loading small arms using brass cartridge cases were being developed. Picric acid, which had been known to chemistry for 175 years, was at last utilized as an explosive mixture.

43. Franco-Prussian War.

a. The Franco-Prussian War of 1870-1871 found the Prussian infantry still using their needl gun, with an effective range of 700 yards, whereas the French had a more modern breech-loading rifle, effective at 1300 yards. Napoleon III also used the mitrailleuse, a form of machine gun. In spite of this superiority

in small arms, the French were disastrously defeated. The German victory may be attributed to superior staff work, superior training, and especially to superior field artillery. The weaknesses of Prussian artillery in 1866 had been remedied, and although the French had actually a greater proportion of cannon per 1000 rifles than the enemy, their artillery was outpowered, outmaneuvered, and outfought. The Prussians used steel breech-loading rifled guns firing, at the rate of two rounds per minute, a percussion shell which broke into about 30 fragments. The French gun fired equally fast, but the shell fragmentation was only half as effective as the German. The French had a time-fuzed projectile filled with 85 balls, but the fuze was capable of only three settings and many duds resulted. The average range used by artillery in this war was 1500 yards. Iron gun carriages appeared.

b. German infantry at first attempted to assault without adequate artillery support. At St. Privat it suffered tremendous losses from French small-arms fire. But at Sedan such a devastating cannonade was employed that the Imperial French army was overcome at a cost of only five percent casualties. Sedan was the greatest artillery battle prior to the World War. The relative effectiveness of the opposing artillery can be seen from the fact that German losses in the war were only 8 percent from cannon fire, 91 percent from infantry fire; whereas the French suffered 25 percent casualties from artillery projectiles and 70 percent from small arms. With all this effectiveness, the German artillery fired less than 358,000 rounds during the entire war from a total of 1718 cannon. This experience undoubtedly had something to do with the miscalculations which they and all other belligerents made in estimating ammunition requirements for the World War.

c. The results of the war of 1870-1871 startled the world. German military doctrines and materiel became the model of many nations for a generation. Some of the lessons relearned were: (1) The value of massed artillery, (2) the value of mobility, especially of pieces capable of early entry into action, (3) the necessity of neutralizing hostile artillery fire power before an infantry attack, and of preparation fire for the immediate attack, (4) the necessity for close infantry-artillery liaison, (5) the inadequacy of flat-trajectory weapons against troops in trenches.

44. American developments between 1865 and 1880.

a. Following the Civil War, artillery development consisted of experimentation with pilot models. Wrought-iron carriages were tried. Many improvements were devised, such as moving the limber pintle to the rear of the axle to relieve the necks of the wheel horses of the weight of the pole; lowering the trunnions to improve traveling stability; increasing the ground clearance; providing interchangeability of carriages. But the country was weary of war, appropriations were cut, and because there was a large stock of old wooden carriages on hand most of the projects were dropped.

b. A type of machine gun, invented by Dr. Gatling, became part of the artillery equipment. This weapon, which could fire 350 shots per minute, consisted of 10 parallel barrels rotated and fired by the turning of a crank. It appeared during the Civil War, but was not much used. By 1872 it had been generally adopted in Europe, where it proved more popular than the French mitrailleuse.

c. Rodman's system of cooling the molten cannon casting from the interior, and improvements in powders, revived the hope of using cast iron for rifled cannon, in spite of the fact that by 1871 steel had definitely displaced other metals in Europe. The experiments were unsuccessful. The steel industry in the United States was still undeveloped. American field artillery suffered a general decadence. War lessons were forgotten. The artillery was reduced to five regiments, each regiment a mixture of field and coast batteries. The two light batteries assigned to each regiment were separated from their colonel and stationed at remote interior posts, where the battery commander was the reigning nabob.

d. In 1880, the American field artillery was still equipped with muzzle-loading smoothbores of Civil War vintage. However, there had been added a 1.65-inch steel breechloader for mountain use, a 1.45-inch revolving steel cannon, both of Hotchkiss design, and long and short types of .45-inch Gatling guns. Except for the mortars and the very largest calibers of guns, most of the heavy siege and seacoast ordnance had been converted into rifles by fitting them with wrought-iron tubes.

e. The American infantry at this time was equipped with a .45 caliber single-shot breech-loading Springfield rifle.

45. European developments between 1871 and 1885.

a. In 1877-1878, a war was fought between the Turks and Russians in which smokeless powder appeared for the first time. The Turks used Winchester repeating rifles with metallic cartridges. At the siege of Plevna it was observed again that light flat-trajectory weapons were unsatisfactory against troops behind cover. The Russians were forced to supplement their 107-mm. high-velocity gun with a 120-mm. "short gun" in order to obtain curved fire and greater projectile effect.

b. In 1880, Great Britain readopted breech-loading cannon, abandoned since 1864. Steel began to displace cast iron for use in explosive shell. Segmented and ringed projectiles were tried and abandoned. In 1883 the Swiss Major Rubin produced the first successful .30 caliber high-velocity rifle. This type was soon adopted by other European countries, notably by the Germans with their Mauser repeater of 1884. The United States did not adopt a similar type until 1892.

c. In cannon construction, the built-up steel construction, consisting of a steel tube with hoops shrunk on, was winning out.

46. American Ordnance Board of 1881.

a. In 1881, the rifled breechloader was at last recognized in the United States as the proper weapon for field artillery. An Ordnance board appointed that year recommended as a temporary expedient the adoption of a 3.2-inch breech-loading gun, to be converted from the old 3-inch muzzle-loader by using a "round-back wedge fermeture (plug)." The board was of the opinion that the field artillery should have steel guns of two calibers with muzzle velocities of not less than 1600 f/s—one to be a light gun firing a shell of about 13 pounds weight, the other a heavier weapon firing a shell weighing about 22 pounds. The board also contributed this statement: "The board has not lost sight of the value of vertical fire in all field operations and the likelihood of its greater development in consequence of the influence of intrenchments, rifle pits, forts, and other temporary covers to which troops resort when confronting each other. To provide for this kind of fire, the board recommends a short rifled steel howitzer

or mortar of not less than 5.5-inch caliber, and of a weight not to exceed 1000 pounds, the same to be mounted on an iron or steel carriage. The usefulness of such batteries would be very great."

b. The board also recommended a uniform construction of interchangeable wheels, road brakes, elevating mechanisms to allow curved fire with reduced charges, seats for cannoneers on the carriage, folding trail handspikes, and many other advanced ideas. However, the most significant and revolutionary recommendation was the following: "Gun carriages to be of steel in two parts; that on which the gun rests to have a small movement, checked by an elastic buffer."

c. It is to the everlasting credit of the Ordnance Board of 1881 that the major part of their recommendations have been justified by the passage of time, in spite of the skepticism of most conservative military opinion of their day. The specifications for a field howitzer which they laid down are pretty close to those which proved so successful for the Germans in the World War 35 years later. Today, 58 years after the board submitted its recommendations, we are still debating earnestly over the specifications of such a weapon.

d. About 1881, Birkhimer, from whose volume much of the post-Civil War information has been obtained, criticized the system of dual responsibility of the Ordnance Department and the Field Artillery for the development of field artillery materiel. He preferred a single system, as was in vogue in France. An artillery man of the old school, he was very skeptical about the proposal of a recoil mechanism for mobile cannon, in spite of the fact that pneumatic or hydraulic recoil brakes were already in service on seacoast armament in the United States. He was also skeptical about the value of elevating mechanisms.

47. **Invention of smokeless powder.**—In 1865 Major Schultze of the Prussian artillery produced the first smokeless powder, but the first really good smokeless powder was produced by Vielle, a French engineer, in 1884. Shortly thereafter appeared melanite, ballistite, and cordite. All nations immediately took steps to revolutionize their ammunition, and the development of propellants and high explosives, using the principle of nitration of organic compounds, proceeded apace. Black powder was finally

displaced after a reign of almost 600 years. The high velocities and increased ranges now possible caused radical changes in gun design and revolutionized the science of land fortifications. Developments were equally great in small arms, being marked by the appearance of numerous automatic and semiautomatic weapons, such as the British Maxim and Vickers machine guns, the French Hotchkiss (from an American invention), and the German Schwarzlose. Cupronickel was introduced for rifle-bullet jackets.

48. **German experiments.**—In Germany, beginning with the reign of William II in 1888, the Krupp Company grew into one of the world's leading cannon foundries. The German artillery about this time conducted some experiments which are of note in the light of later events. Their officers who had observed the effect of artillery fire in actual operations were among those impressed by the relative ineffectiveness of flat-trajectory fire against troops occupying cover. They tried experiments with shrapnel, using reduced charges, but achieved no particular success. They then introduced a 120-mm. "short gun" firing a time shell. Although proving-ground tests were successful, the weapon failed in the hands of troops, probably for the same reason that made shell unpopular in the British and other services; namely, because the rudimentary fuzes gave too many premature bursts. The shrapnel tradition was strong in the German army as elsewhere, and the conservatives successfully maintained that the occupation of cover by troops was a "special situation." The Germans tried out a 150-mm. mortar but gave it up because the ammunition was considered too heavy for the transportation facilities of the period. However, the curved-fire advocates were successful in forcing the test of a rifled light field howitzer of 105-mm. caliber, the projectile of which was rated four times as effective as that of the field gun. The results of the Boer War a few years later convinced the Germans that such a weapon was needed, and it was made a part of their artillery establishment.

49. **European artillery between 1890 and 1895.**

a. By 1890, nitrocellulose and nitroglycerine-base powders had generally replaced black gunpowder as a propellant. Picric acid was used as a high explosive in armor-piercing shell. By 1895, smokeless powder was being used in small arms by practically all countries except the United States.

b. Great Britain, Italy, and Japan began to use the "wire-wrapped" construction in guns. The Germans never adopted that system, preferring the built-up construction. Most guns were made of alloy or carbon steel. The ammunition in use was shrapnel or high explosive shell with a base fuze. Crude recoil mechanisms began to appear on field pieces. Direct laying was still the normal method of firing.

c. In 1891, the German General Wille published a work entitled "The Field Gun of the Future" in which he predicted revolutionary changes, such as quick-firing guns, recoil mechanisms, and radical improvements in projectiles. A year later, Colonel Langlois published in France a similar prophecy, in which he announced that the future gun would "transfer to 3,000 yards the point-blank and case-shot fire of the smoothbore." Most of these predictions were realized in a very few years. However, it is to be noted that most of the prophets failed to anticipate the possibilities in the use of cover that were available to the infantrymen since the perfection of the breech-loading rifle; they still thought in terms of lines of infantrymen in close order, advancing by platoon rushes, loading, and firing from the standing or kneeling position.

50. **French 75-mm. gun M1897.**—In 1897, the famous French 75-mm. gun was brought forth and its characteristics made known to the world. This remarkable weapon was produced by the firm of Schneider at Creusot. A number of individuals have been credited with the invention, including Canet and Deport; it was probably an evolution of considerable duration and represented the efforts of many minds. Its appearance ushered in a new era; after 42 years it is still considered the premier weapon of its type. The details of its construction are known to all field artilleryman. In 1897, the most revolutionary of those features were the built-up construction of alloy steel, the hydropneumatic long-recoil mechanism, the simple but effective breech block, the manner of elevating and traversing, and the light weight and ruggedness in relation to power and rapidity of fire. An improved ammunition with a point-detonating fuze, fired to a maximum range of 6000 yards, was as important an innovation as the gun itself. At once all other field artillery cannon became obsolete, and every nation set to work to redesign its materiel in order to

produce a gun approximating the characteristics of the Soixante-quinze. Krupp in Germany shortly produced a satisfactory hydro-spring recuperator of simpler construction than the French, though less mechanically efficient, and this, along with the other advanced features of the French 75, was soon adopted by all the major powers.

51. Summary of the transitional period.—The five great developments in this, the shortest but most fruitful period in the history of field artillery, were: (1) The replacement of smooth-bore cannon by rifled pieces, (2) the replacement of bronze, cast iron, and wrought iron, by steel, (3) the perfection of breech mechanisms, (4) the introduction of the long on-carriage recoil mechanism, (5) the perfection of smokeless powder and high explosives. Hardly less important than these were the development of rapid elevating and traversing mechanisms, and efficient sighting systems. The muzzle-loading smoothbore, firing spherical solid shot, spherical shell, cannister, and grape, with a black-powder propellant, finally went out of the picture after a reign of almost 700 years. In its place there appeared a highly mobile weapon, comparatively light in weight, firing a far deadlier projectile to at least four times the range of the older pieces, and at a sustained rate of several rounds per minute. In spite of equivalent improvements in infantry weapons, which forced artillery batteries to emplace still farther to the rear, the artillery, by means of a new indirect-firing technique, was again able to dominate the battlefield by fire power.

MODERN PERIOD (1897-1939)

52. Spanish-American War.—In 1898, the United States found itself engaged in a war with Spain before we had an opportunity to progress far with modernization of materiel. Our mobile land armament was decidedly antiquated. Spanish equipment, what there was of it, was more up-to-date. At El Caney, Cuba, Capron's battery used 3.2-inch nonrecoiling guns, firing unfixed black-powder charges, the dense white smoke from which made the battery a conspicuous target for hostile fire. In the matter of small arms the regulars were better equipped, having the Danish Krag-Jorgenson rifle, M1892. However, many of the volunteer troops and militia carried obsolete single-shot Springfield's using black

powder. Fortunately, the United States had an overwhelming naval supremacy, which prevented the movement of Spanish reinforcements to the theater of operations. Land engagements were few and of such nature that field artillery was little used. A quantity of 2.95-inch mountain guns, of Vickers-Maxim type, were purchased from the British. This little weapon, in reality a howitzer, had a hydrospring recoil mechanism, and broke down into four loads for pack transportation. It is still in active service with the pack artillery of the Philippine Scouts.

53. Boer War.—In 1899 the British embarked upon the Boer War, which lasted three years. Their artillery consisted principally of 12- and 15-pounder Armstrong guns, of built-up steel construction. They had no light howitzers, but about 10 percent of the pieces were heavy 5-inch howitzers, the shell fire from which had proved especially effective in the Sudan campaign a year earlier. Boer artillery, largely French and German 75-mm. guns, had a range of 5000 yards as opposed to the British 3500, an advantage which contributed to the stubborn defense put up by the Dutch colonists against the resources of the British Empire. The English relied principally upon shrapnel fire, the excessive faith in which was not justified, according to foreign observers.

54. American developments between 1900 and 1914.

a. In order to bring American artillery abreast of the times, the Ordnance Department secured a number of models of up-to-date field pieces and subjected them to comparative tests, in the years 1901-1902. Some of these were of Ordnance design, some were produced by the Bethlehem Steel Company, and others were British, Belgian, and German models purchased abroad. They were of nonrecoil, short-recoil, and long-recoil types, and employed various kinds of breech mechanisms and sighting systems. Those which appeared to the best advantage were the Ordnance and German Ehrhardt models, but none was entirely satisfactory. The Ordnance thereupon designed a new 3-inch field piece which successfully passed all tests and was produced in quantity for the regular army and the militia as Models 1902, 1904, and 1905. This excellent weapon remained the standard field piece of the American army until the World War. (It had a built-up steel tube, with an increasing-twist rifling, an inter-

rupted-screw breech mechanism, a hydrospring recoil mechanism of the long type, and an excellent sighting system employing a panoramic telescope of German design. The gun could be elevated between minus 5 and plus 15 degrees on the carriage, and traversed 142 mils. It fired shrapnel with a combination time-and-percussion fuze, and high-explosive shell with a base fuze, to a maximum range of 8500 yards. This ammunition was of the fixed type, with a brass cartridge case. At first, some of the component parts, such as recoil springs and panoramic sights, had to be procured abroad, but before 1905 all parts were being manufactured in the United States.

b. In 1903 the American army adopted the Springfield repeating rifle, which was lighter and several inches shorter than the old Krag. Its maximum range was several miles. A trained rifleman could fire 20 shots in 16 seconds, and about one aimed shot every two seconds. This splendid weapon was probably the best infantry rifle in the world until after the World War. It remained the United States standard until 1937, when it was superseded by the Garand semiautomatic rifle, M1.

c. An important change in artillery organization occurred in 1907 when the field artillery was separated from the coast artillery. The initial organization of the field artillery was to be six regiments of six batteries each. In 1908 experiments commenced with pack-artillery design which came to a successful culmination 17 years later in the 75-mm. pack howitzer, M1. In 1913 the test board recommended a divisional artillery organization of 36 3-inch guns and 12 3.8-inch or 4.7-inch howitzers.

55. Russo-Japanese War.

a. The most important war which occurred between 1870 and the World War was the Russo-Japanese War of 1904-1905. In this conflict, Russian artillery materiel was considered better than Japanese, but the tactical handling was much inferior. The principal Russian gun was a 3.9-inch Engelhart rifle, built in England. The Japanese used a 75-mm. Arisaka gun, M1898, patterned after a Krupp model. A lack of light mobile howitzers was sorely regretted on both sides. Howitzers of a heavy type were employed. They were extremely effective when in position, but not sufficiently mobile to follow the troops. The Russians are

said to have used shrapnel exclusively in their field guns; the Japanese also used much shrapnel, but resorted to shell fire against troops in trenches. Military observers again noted the ineffectiveness of flat-trajectory fire against troops in villages, or under light cover in the open, and recommended to their governments a more extended use of mobile howitzers. After the war, both Russian and Japanese artillery increased the proportion of high-angle-fire weapons.

b. From the very beginning of the war the Japanese employed the French system of indirect laying, whereas the Russians attempted direct laying, emplacing their guns in exposed positions, with the result that their fire was relatively ineffective and their losses heavy. Official casualty tables verify this criticism, crediting Japanese artillery with 14 percent of Russian losses, and Russian artillery with only 8.5 percent of Japanese losses. The relatively small losses on both sides from artillery fire, as compared to the Franco-Prussian War and the World War, may be attributed in part to the lack of high-angle fire and the excessive use of shrapnel; this in spite of the fact that ammunition expenditures were vastly greater than in any previous war. The proportion of cannon to infantry was about 3.5 per 1000 rifles in both forces.

c. This was the first war between major powers in which smokeless powder and small-caliber clip-loading infantry rifles were used. An interesting reappearance on the battlefield was the hand grenade.

56. European developments prior to 1914.—As a result of the Russo-Japanese War, all European armies turned their attention to howitzers of calibers between 105-mm. and 120-mm. An organization of about 18 such pieces per division was considered in the Austrian and German artillery. By 1910, some sort of light howitzer had been adopted in every country except France, which continued to experiment with them, but never went into quantity production, being convinced of the adequacy of the 75-mm. gun. Experiences in the early Balkan wars of this period verified the importance of the howitzer. It is interesting that tests conducted in France in 1912 indicated that the 105-mm. howitzer was superior to the 75-mm. gun as an *accompanying* weapon, being able to get closer to the front lines without exposing itself, and being able

to find positions faster than the gun. Nevertheless, French materiel in the hands of the Balkan nations in the wars of 1912-1913, as opposed to German materiel in the hands of the Turks, was reported as superior, and the French apparently discounted the results of their own experiments. Austria and Germany evidently derived a different lesson from the same observations. The Austrians secretly built a number of 305-mm. heavy mortars with motorized transportation, and Krupp proceeded with the development of even heavier mobile howitzers. Von Eberhardt at the Krupp works began a series of important experiments to determine the effect of air resistance on projectiles of various shapes and weights.

57. World War.

a. When the World War began in August, 1914, it found the British and German divisional artillery organized and armed along similar lines, although the German army contained more units. The German division had 54 guns of 77-mm. caliber and 18 light field howitzers of 105-mm. The British had 54 guns of 18-pounders (3.2-inch) caliber, and 18 light field howitzers of 4.5-inch (114-mm.). The British division also contained four 60-pounder guns. Both of these powers continued to organize their batteries with six pieces. The French division, on the other hand, contained only 36 guns of 75-mm. caliber, organized in batteries of four guns.

b. The discrepancy in total number of pieces between the French and German divisions was somewhat offset by the fact that French corps artillery habitually performed counterbattery missions. French corps artillery contained additional regiments of 75-mm. guns, and also units of heavy and foot artillery. British siege trains contained 8-inch howitzers. The German corps had 150-mm. howitzers, and their army had a number of large 210-mm. howitzers.

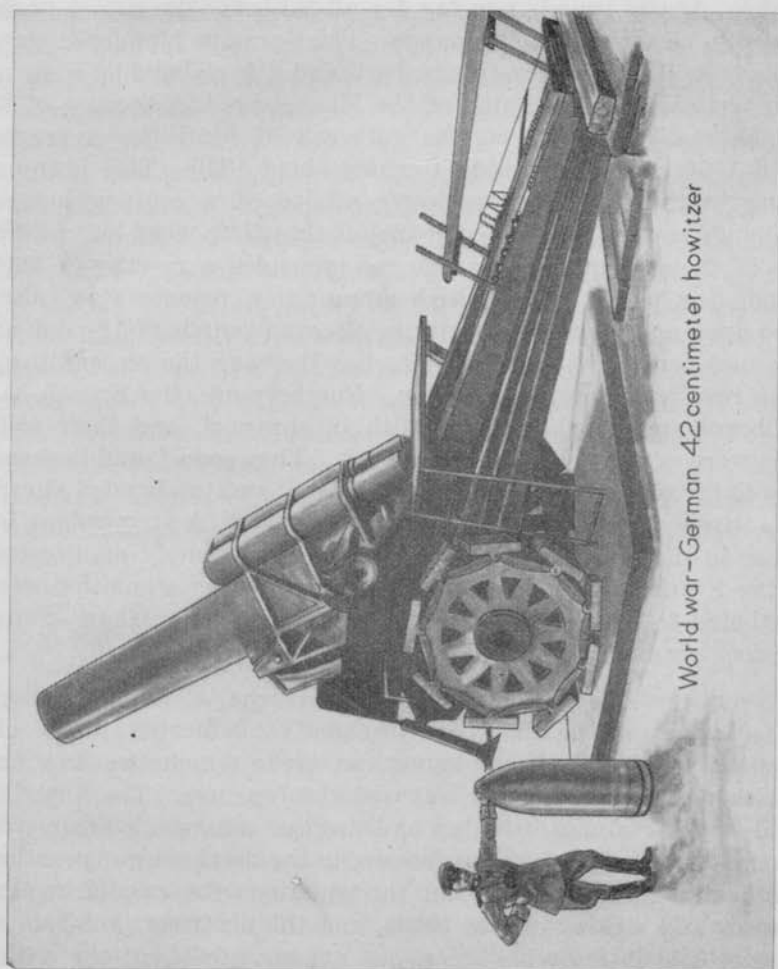
c. The proportion of cannon to infantry rifles was 6.4 per 1000 in the German army. In the French army it was 4 per 1000, the same as in 1870. If Germany artillery attached to divisions from higher echelons be added, the German proportion was about 8 per 1000. The figures show that the French were at a tremendous

FRENCH ARTILLERY DURING THE WORLD WAR				
Type	Number of pieces		Maximum range—yards	
	1914	1918	1914	1918
75-mm. guns	3840	5494	6000	11000
Medium and heavy field artillery (modern)	308	5000	6500-10700	13000-21000
Railway and seige artillery	0	711		30000-40000
Antiaircraft artillery	1	404		
Trench artillery	0	1680		

FIGURE 15.—French artillery during the World War.

disadvantage in the matter of light and medium howitzers (FIG. 15). The Germans not only had more artillery power, but they achieved a better balance between power and mobility, and their artillery-infantry liaison was initially better developed. Just why the French allowed themselves to be caught in such a predicament, in the light of observations made in nearly every war since 1870, is incomprehensible. It is true that an element in the French army had pointed out the deficiency before the war, but the voice was not heeded. Almost from the outset the flat trajectory of the 75's put them at a disadvantage. The French were forced to adopt the inefficient expedient of placing a disk of metal in front of their 75-mm. shell in order to increase air resistance and thus obtain the necessary curvature of trajectory for close-support missions. The artillery deficiency undoubtedly was an important factor in the French defeat in the early battles of the frontier.

d. The first surprise of the war was the speedy reduction of the great Belgian and French fortresses. This was accomplished by means of the large mobile howitzers and mortars which the Central Powers had secretly built before the war. The forts at Liege, Maubeuge, and Namur were smashed by Austrian 12-inch mortars of Skoda make that had been transported in sections by motor trucks. Steel and concrete defenses constructed to be proof against 8-inch projectiles crumbled within a few days when subjected to the high-angle fire of such enormous projectiles. Later, at the siege of Antwerp, the Germans brought into action an even larger weapon, the famous Krupp "Big Bertha" of 420-mm. (16.5-inch) caliber (FIG. 16). These huge howitzers, transported in sections behind mechanical prime movers, threw a shell weighing 1570 pounds to a range of six miles.



World war-German 42 centimeter howitzer

FIGURE 16.—German 42-cm. howitzer.

e. In the matter of ammunition for artillery, all the belligerents found that they had hopelessly underestimated the requirements. After only six weeks of war there was an ammunition crisis. French war plans contemplated a production requirement of about 14,000 rounds per day for all calibers; the actual needs proved to be about 280,000 rounds. The Germans blundered quite as badly as the French in this respect, and it is claimed by some of their writers that the Battle of the Marne was lost because of it. French stocks on hand at the outbreak of hostilities averaged about 1060 rounds per piece, German about 1320. This is interesting in the light of Napoleon's advice of a century before. Although ammunition expenditures at that time were but a fraction of those in modern war he recommended a reserve of 3000 rounds per piece. The British ammunition reserve was calculated upon an assumed expenditure of seven rounds of 18-pounder shrapnel per piece per day. During the war the expenditures often rose to 500 rounds per day. Furthermore, the British had stubbornly persisted in their faith in shrapnel, and their field guns were exclusively supplied with it. They soon found it necessary to furnish a large proportion of shell, and to abandon shrapnel entirely for use with the 4.5-inch howitzers. A tremendous increase in the killing power of shell was immediately manifested. In the French forces in 1914, 75 percent of the casualties were attributed to artillery fire, a far larger proportion than in any previous war in history.

f. On the side of the Central Powers the Austrian artillery suffered heavily against the Russians by adhering to its old offensive tactics of direct laying, an error which the Russians had learned to correct in the war with the Japanese. The Austrian artillery officer was criticized as being too intensively trained in the theoretical side of his profession, to the detriment of practical technique. He knew all about the equations for calculating the stresses and strains in gun tubes, and the abstruse problems of exterior and interior ballistics, but not enough about the duties of the battery executive. The Germans, for their part, admit that they had overemphasized mobility in prewar training of light artillery, having spent too much time on the intricacies of maneuvers limbered, and not enough time on the practical occupation of position and the firing of the guns.

g. After the Battle of the Marne, the war in the west entered into a stabilization period which lasted four years, resulting in virtually a siege condition along the entire front. The French and British took immediate steps to increase their proportion of medium and heavy artillery. Trench warfare forced developments which may not have occurred had operations been continued in the open. A reaction towards power and range proceeded at the expense of mobility. Ranges for divisional weapons increased to 10,000 yards. Heavy armament of all types, including railroad mounts, was pressed into service. Mortars and hand grenades were invaluable. Shrapnel was almost worthless under the prevailing conditions. Against troops in trenches or in partial cover, shell with a time fuze was found to be the most effective projectile. The Germans were supplied with such ammunition from the first, but because of difficulties in manufacture and problems of adjustment of time fire, they, as well as all other belligerents, were forced to rely chiefly on shell with a percussion fuze. A super-quick, point-detonating fuze was used against personnel. For the demolition of trenches, dugouts, and concrete cover it was found necessary to employ high-explosive shell of 6-inch caliber or greater, with a delay fuze, preferably delivered with high-angle fire.

h. Numerous innovations in materiel and technique appeared. Chemical shell was introduced by the Germans in 1915, and was thereafter adopted by other nations. Smoke shell was extensively employed after 1916. Observation by balloon and airplane for medium and heavy calibers became necessary; wire and radio communications were greatly developed. Precise firing was emphasized to a degree hitherto unknown, resulting in refinements in survey operations, and a dependence upon maps and meteorological data in the preparation of fire. This was forced by the requirement for fires at night or at other times without observation; later it was made necessary by the requirement of tactical surprise. Motor transportation began to supplant the horse, beginning with the heavier calibers. The tank appeared as a new offensive threat, which created a new type of target requiring flat-trajectory fire. Another menace, the airplane, with its cameras and bombs, made the use of camouflage and cover a matter

of prime necessity, and brought forth a new form of artillery with a superflat trajectory, the antiaircraft gun.

i. The power of the defense had grown so great that no advance could be made without a tremendous superiority in artillery fire, which in turn necessitated an enormous increase in artillery weapons in proportion to infantry. In 1917 in certain sectors there were actually more artillerymen than infantrymen. The barrage became the normal method of fire, involving unheard-of expenditures of ammunition. In most attacks guns were used in the proportion of one per 10 yards of front; in some decisive sectors the proportion was one per 5 yards of front. Coordination of such masses of fire necessitated centralization of command. To offset the unwieldiness of centralization in the attack and to provide a certain amount of instantaneous local support, a return to the system of attaching a part of the artillery to infantry assaulting units became necessary. To conserve animals for the war of mobility anticipated in the decisive phase, it was necessary to remove horse lines far to the rear of the guns. Those which remained forward suffered extraordinary losses, as the problem of protecting animals from shell fire, bombs, and gas was much greater than the protection of men.

j. As the war progressed, the Germans reduced the number of guns per battery to four, because of a shortage of transportation. Both the Germans and British found it advantageous to mix howitzers and guns in the same battalion, the usual proportion being two gun batteries and one howitzer battery per battalion. A German report in 1917 recommended that the proportion be changed to provide a preponderance of howitzers, but stipulated that the range of the howitzer be increased. Streamlined projectiles came into use in all armies, accentuated by the use of false ogives.

k. By the end of 1917, the Central Powers had finally destroyed active resistance on the eastern front. To win in the west before the American strength could be assembled, they applied in the spring of 1918 all the reserves at their command. Their artillery preparations, using the Bruchmuller-Hutier methods so successful against the Russians, marked the high-water level of scientific use of the arm. The German spring tactics included absolute secrecy and surprise in concentrating an over-

powering amount of artillery, and the preparation of fire of this artillery without adjustment in such a manner as to utilize all calibers to the limits of their ranges. A short hurricane bombardment was delivered, designed to paralyze rather than destroy the resistance. Counterbattery fire, with much use of gas and smoke, was an important element. Rolling barrages protected the initial stages of the assault, and measures for prompt forward displacement were provided. With this new technique the Germans achieved startling tactical successes against the British in March, and against the French in May. But the balance of power was too nearly equal to permit more than a limited success. After the Chemin des Dames reverses, the French countered by withdrawing out of range of the initial preparations, and by putting down powerful counterpreparations. By July the arrival of American divisions gave Foch the necessary reserves for a counteroffensive, which developed into a grand allied advance along the entire line. As soon as its materiel was overpowered, the morale of the German army broke, and the war was over.

l. In the final analysis it was *fire power* that decided the issue. By 1918 the proportion of artillery had grown to 10 cannon per 1000 rifles, of which 6 pieces were light guns and howitzers, 2 medium, $1\frac{1}{2}$ heavy, and $\frac{1}{2}$ superheavy. Considering the French army alone, the proportion was 15 cannon per 1000 rifles. (FIG. 15). There was a marked dropping off in effectiveness of German artillery fire in the latter months of 1918, as evidenced by the fact that French losses from artillery fire were only 58 percent, a reduction from the figures of 1914-1917.

m. At the armistice, British materiel consisted mainly of 18-pounder (3.2-inch) guns, 6-inch guns, 8-inch howitzers, and 9.2-inch howitzers. French and American artillery consisted mainly of 75-mm. guns, 155-mm. howitzers, and 155-mm. guns. The American forces, for reasons of procurement, training, and supply, had adopted French materiel and technique. German materiel comprised 77-mm. guns, 105-mm. howitzers, 150-mm. howitzers, 150-mm. guns, and 210-mm. howitzers. The Germans, either as a matter of greater flexibility or to meet special requirements in different theaters of war, employed various lengths of tubes on light and medium weapons of the same caliber. At the armistice, they had still a large reserve of guns and howitzers, but

their ammunition suffered from an acute shortage of copper, for which they were forced to use substitutes. This was especially important because all their field weapons, including the larger calibers, required a metallic cartridge case for obturation.

n. In all armies, the tendency had been towards greater ranges with howitzers and reduced charges with guns, causing the distinction between guns and howitzers to diminish. These compromises were in response to the conflicting demands for greater ranges, more powerful projectiles, and curved fire, all held down by mobility requirements. It will be observed that the French, when they adopted a divisional howitzer, did not select a light weapon similar to that of the British and Germans, but chose the heavier 155-mm. (6.1-inch). This was done because of the stabilized conditions existing on the western front at the time, where power rather than mobility was considered the predominant requirement. In 1918, anticipating a siege of German frontier fortifications the following year, the French developed a mortar of 520-mm. (20.5-inch) caliber.

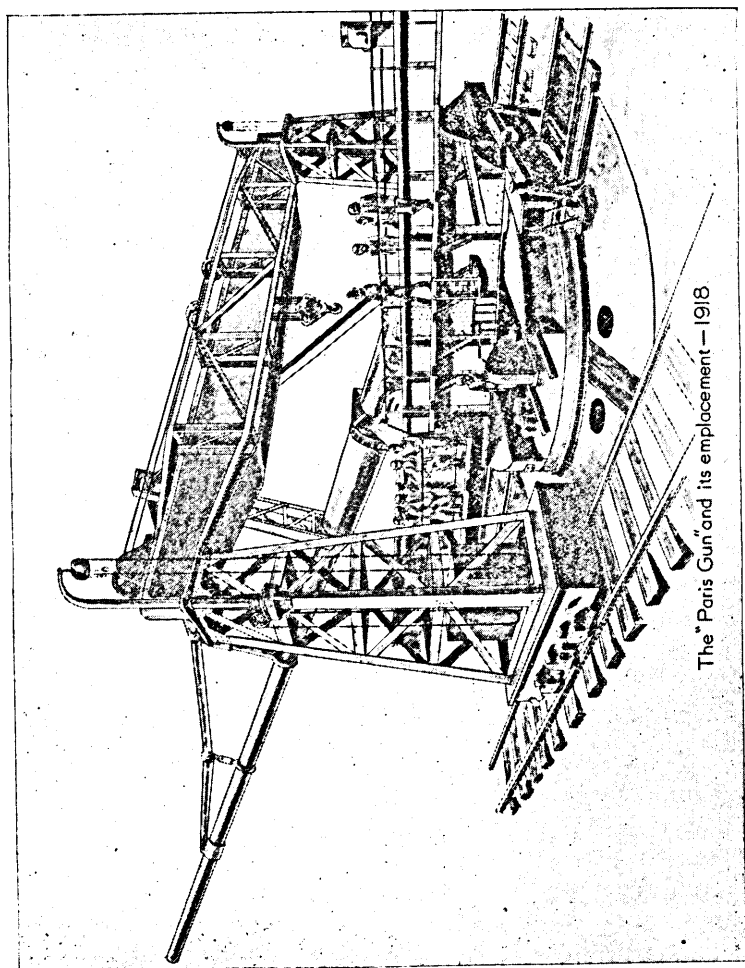
o. In the year ending November 10, 1918, the Allies expended 160,615,000 rounds of ammunition. In the American Civil War, the Union army expended in the year ending June 30, 1864, only 1,950,000 rounds. American artillery at St. Mihiel fired 1,000,000 rounds in a single four-hour preparation. During the World War the average field gun fired 33 rounds per day, as compared with a Civil War average of four rounds. The cost of ammunition in the Civil War was \$10,000,000; in the World War it amounted to \$30,000,000,000. The total cost of the World War to the United States is estimated to be almost \$42,000,000,000. Of this amount nearly \$16,000,000,000 was appropriated by Congress for Ordnance purposes, over half of which was spent for *artillery ammunition*. It should be remembered that the ammunition fired from an artillery piece during the normal life of the weapon costs from 13 to 50 times as much as the weapon itself. The United States, in spite of its vastly superior industrial facilities, at the end of the war was producing only 412 artillery pieces per month, as compared to 486 for the British, and 659 for the French. Our ammunition production per month was 2,712,000 rounds, the British 7,347,000, the French 7,638,000. Nearly all the artillery weapons and ammunition used at the front by American forces were of French or British manufacture.

p. To summarize the World War developments, it may be said that the revolutionary improvements of the Transitional Period were standardized and consolidated. The balanced trunnion carriage, the single box trail, and the low-speed axle construction reached their apogee. The Krupp 420-mm. howitzer represented the weapon with the greatest destructive effect to appear on any battlefield. (FIG. 16). The Paris Gun (PAR. 58) demonstrated probably the most to be expected in the matter of extreme range with the metals and explosives now known to science. It was demonstrated that no military force can hope to execute a successful attack against an intrenched enemy without an overwhelming superiority in field artillery. Superior infantry in the attack can be stopped by only two things—death or the fear of death. Although the machine gun at close quarters is admittedly the bulwark of any defense, medical statistics of all major powers in the war show that 70 to 85 percent of the actual casualties were caused by artillery fire. This is the truest index of the decisive role of field artillery on the modern battlefield.

58. German long-range gun.

a. (FIG. 17). The most unique technical development during the war was the German long-range gun, which surprised gun designers and ballisticians the world over. The idea of the gun was conceived by Von Eberhardt, who drew up the original calculations. The construction was done at the Krupp works, in collaboration with the German navy. The actual operation of the gun was by the navy.

b. From March to August, 1918, a succession of these guns fired a total of 367 rounds of high-explosive shell into Paris and its suburbs. Five different gun positions were used, in three widely separated localities. The mean ranges attained were about 75 miles from the St. Gobain Forest area, about 69 miles from the Beaumont position, and about 57 miles from the Bruyeres emplacement in the Marne salient. The maximum range was about four times that obtained by the German 15-inch naval gun which shelled Dunkirk in 1915. A total of nine guns were manufactured, of which seven were actually fired at the front. One of these burst on its third round.



The Paris Gun and its emplacement — 1918.

FIGURE 17.—German long-range gun.

c. The caliber of the guns was initially 210-mm. (8.26-inch); when worn out after their short life of 50 to 60 rounds at maximum-range firing, they were rebored to 232-mm. (9.14-inch). The life of the rebored tubes, which fired at shorter ranges, varied from 100 to 200 rounds, as estimated by their condition when the bombardment ceased. The guns were constructed of two 15-inch naval guns screwed together, fitted with a smoothbore extension at the muzzle about 20 feet long. The total length of the bore, including the powder chamber, was 118 feet, or a little less than 175 calibers. The muzzle had to be supported by a truss to prevent droop. In firing, the gun was set at a constant elevation of about 50 degrees, the ranges being changed by varying the powder charge. The probable point of impact was determined by measuring the chamber pressure at each shot and the position of the projectile when loaded; the plotting was then checked from the Paris newspaper accounts received via Switzerland the following day. The maximum muzzle velocity obtained was about 5500 feet per second. Dispersion varied; with a new gun it was about two miles in range and three-quarters of a mile in direction. Firing data had to be computed with great care for each round. In addition to the usual weather corrections, computations had to be made for the curvature of the earth and the rotation of the earth, the velocity of which varied between the gun and target.

d. The projectile, about 40 inches long, was a high-explosive shell constructed in two parts with a separating diaphragm and was fitted with two fuzes. To reduce wind resistance, a long false ogive was provided. Two narrow copper bands, widely separated, gave the necessary gas seal, but the steel walls of the shell in front of each band were also grooved to fit the rifling. The shell walls were much thicker than those of an ordinary high-explosive shell to give a greater sectional density; this resulted in a relatively small explosive charge, which was about the same as that in a French 155-mm. shell. A brass cartridge case was used for obturation. The 8.26-inch shell weighed 264 pounds; the 9.14-inch projectile weighed 273 pounds and required a powder charge of about 430 pounds. Chamber pressure measured in firing varied between 42,000 and 69,000 pounds per square inch. The maximum ordinate of the shell was 24 miles, and the time of flight for the maximum range was 186 seconds. The maximum rate of

fire was four rounds per hour. The secret of the phenomenal range lay in the great muzzle velocity, the ballistic efficiency of the projectile, and the high angle of elevation. During the greater part of its flight the projectile passed through the upper strata of atmosphere where the density was only about one-tenth that at the surface of the earth, a condition approaching travel in a vacuum.

e. The emplacements used were of different types, some being of concrete and steel, others of wood and steel; all required weeks to prepare. The last guns fired were mounted on a huge railroad carriage which was run onto a turntable. About three days were required to install a gun and carriage after the emplacement and railroad sidings had been completed; a huge electric crane was used in this operation. The total weight of the gun and carriage of the railroad-mount type was about 400 tons. Elaborate arrangements were made to camouflage the exact location of the emplacements. At least three other heavy guns were simultaneously fired from the same general locality to confuse the allied sound-ranging stations. Although the approximate locations of the great guns were soon determined by the French, and the locality subjected to heavy bombardment, direct hits were obtained on only one emplacement, and that after the gun had been removed.

f. Because of its cost, and the limited effect of its projectile, the Paris Gun did not pay for itself in material effect upon the enemy. Nevertheless, it had unquestioned moral effect in the early bombardments, causing frequent general alarms and virtually stopping all normal business activity for many hours. Had the Germans been able to hold their territorial gains of the spring offensive of 1918, these guns could have been emplaced at shorter ranges where the life of the tubes would have been much longer. Although such a weapon is not as efficient or as accurate as a bombing plane for long-distance bombardments, it is a mistake to assume that similar guns will not appear again.

59. Westervelt Caliber Board.—A month after the armistice a board of artillery and ordnance officers, headed by Brig. Gen. Wm. I. Westervelt, was appointed by the War Department to make a study of the armament, caliber, type of materiel, kind and proportions of ammunition, and method of transport to be as-

signed to a field army. This board made its report in May, 1919. It analyzed in the light of recent battle experience the probable future needs of supported troops. Taking into consideration the stock on hand and probable postwar reductions in appropriations, it classified the materiel recommended into two categories: The *practical* types possible of immediate development, and the *ideal* types for further development. A summary of the board's conception of the problem is shown in Figures 18, 19, and 20.

60. Postwar experimentation.

a. After the war much experimentation was done in all countries with pilot models. However, for about fifteen years there was no production in quantity of new land artillery except anti-aircraft weapons because the victors possessed large stocks of war materiel and the vanquished were restricted by the Treaty of Versailles. Considerable improvement was effected in mechanical means of transportation, and nearly all nations "modernized" their horse-drawn carriages for actual or possible automotive prime movers. The early modifications consisted of portee trailers or "bogies;" later the carriages were fitted directly with high-speed running gear. Absorption of road shock was accomplished by means of spring carriers, by pneumatic rubber tires, or both. For use with anti-aircraft artillery especially, electrical "directors" appeared, permitting the rapid application of firing data and the mechanical or electrical laying of the guns. Because of their complexity and cost, electrical directors have not been applied to other types of mobile land artillery.

b. In the United States an attempt to realize the ideals of the Caliber Board resulted in the production of an "all-purpose" 75-mm. gun. Although a remarkable accomplishment in design, this weapon, as is often the case with compromises, proved inadequate for either of its primary purposes. It did not have the necessary characteristics of a first-class anti-aircraft gun, and was too heavy and complicated for divisional supporting missions. The result of the experiment was a return to specialization of weapons.

c. The use of removable liners for gun tubes was introduced. While mechanically successful, the device has not been applied to any but guns of unusual muzzle velocity, because, for the lighter

PIECES

		PRACTICAL	IMPROVEMENTS DESIRED	IDEAL WEAPON
Light Field Artillery (Division).	Gun.	50%, Fr. 75-mm. — 1897. 50%, Am. 75-mm. — 1916.	Continue experiments on carriages, perfect the split-trail carriage, and study a carriage for all-around traverse.	Approx. 3" caliber, ranges 11,000–15,000 yds., 80° elev., 360° traverse, rate of fire 20 rds. per min. Carriages interchangeable with light howitzer.
	How.	For the present 155-mm. How. 1918. (Schneider).	Development of howitzer of specifications listed under <i>Ideal</i> .	Approx. 105-mm. caliber, max. range 12,000 yds., 65° elev., 360° traverse. Carriage interchangeable with light gun.
Medium Field Artillery (Corps).	Gun.	4.7" gun—1906 5" gun, British. (Recommended for purchase).	Continue experiments on 4.7" carriages, develop a split-trail carriage, study carriage for all-around traverse.	Caliber 4.7" to 5", ranges 12,000–18,000 yds., 80° elev., 360° traverse, rate of fire 6 rds per min. Carriage interchangeable with medium howitzer.
	How.	155-mm. How. — 1918 (Schneider).	Continue experiments on carriages, develop carriage with high elevation and all-around traverse, interchangeable with that of medium gun.	Caliber 155-mm., max. range 16,000 yds., 65° elev., 360° traverse, rate of fire 5 rds per min. Carriage interchangeable with medium gun.
Heavy Field Artillery.	Gun.	155-mm. GPF.	Study carriage for high elevation and all-around traverse.	Caliber 155-mm., ranges 18,000–25,000 yds. 65° elev., 360° traverse. Carriage interchangeable with heavy howitzer.
	How.	8" How. (British).	No modifications of 8" How. (British) were suggested (This carriage does not lend itself to modification).	Caliber 8", max range 18,000 yds., 65° elev., 360° traverse. Carriage interchangeable with that of heavy guns.

Weapons of Greater Power.	Gun.	None on hand.			
Superweapons.	How.	240-mm. How. M-1918.	Conduct experiments to develop a carriage requiring less time to emplace.	Approx. 8" caliber, max. range 35,000 yds., 65° elev., 360° traverse. Caterpillar carriage.	
	Gun.	8" and 10" guns on railway carriages.	Study carriage design with view to developing a universal mount for sea coast, auxiliary, or railway mounts.	Approx. 9½" caliber, max. range 25,000 yds., 65° elev., 360° traverse. Caterpillar carriage.	
	How.	12" and 16" howitzers on railway carriages.		8" or 10" caliber, max. range 35,000 yds., 50° elev., 360° traverse, rate of fire ½ rd per min. Railway mount.	
Other Artillery.	AA.	3" AA guns.	Continue experiments leading to development of ideal gun.	12" and 16" calibers, ranges 25,000 to 30,000 yds., 25°-65° elev., 360° traverse.	
	Inf. Accom. Gun.	37-mm. gun.	Heavier projectile needed.	3" caliber, M. V. 2600 i.s., 80° elev., 360° traverse.	
	Trench.	No suitable type on hand.	Suitable infantry accompanying gun would replace light trench mortar.	2.5" caliber, range 25,000 yds., 50° elev., 6° traverse, not over 300 lbs.	
	Pack.	75-mm. Vickers.	Continue experiments leading to development of ideal.	6" caliber, range 4000 yds., 40° to 60° elev.	
	Antitank.	37-mm. gun.	Armor-piercing projectile needed.	Approx. 3" caliber, range 5000 yds., 45° elev. Loads not to exceed 225 lbs.	
				75-mm. caliber.	

FIGURE 18. Caliber Board's recommendation—pieces.

AMMUNITION

		PRACTICAL	IMPROVEMENTS DESIRED	IDEAL AMMUNITION
Light Field Artillery (Division).	Gun.	Shrapnel, HE, and chem. shell. Superquick and short-delay fuzes.	Mechanical time fuze. Bore-safe fuzes. Flashless propellant.	Shrapnel, HE, and chem. shell fixed amm., flashless, bore-safe, superquick and selective-delay fuze for shell. Not over 20 lbs.
	How.	For the present 155-mm. HE and chem. shell. Superquick and short-delay fuze.	Development of suitable shrapnel and shell for ideal 105-mm. howitzer.	Shrapnel, HE, and chem. shell, semixed, flashless, bore-safe, superquick and selective-delay fuze for shell. Not over 35 lbs
Medium Field Artillery (Corps).	Gun.	4.7" ammunition on hand.	Bore-safe fuze. Flashless propellant.	Shrapnel HE, and chem. shell, semixed or separate-loading, flashless, bore-safe, superquick and selective-delay fuze. Not over 60 lbs.
	How.	155-mm. HE and chem. shell. Superquick and long-delay fuzes.	Bore-safe fuze. Flashless propellant.	HE and chem. shell, separate-loading, flashless, bore-safe, superquick and selective-delay fuze. Not over 100 lbs.
Heavy Field Artillery	Gun.	155-mm. HE shell. Superquick and short-delay fuze.	Bore-safe fuze. Flashless propellant.	HE shell interchangeable with 155-mm. How., separate-loading, flashless, bore-safe, superquick and selective-delay fuze.
	How.	8" HE shell. Superquick and long-delay fuze.	Bore-safe fuze. Flashless propellant.	HE shell, separate-loading, flashless, bore-safe, superquick and selective-delay fuze. Not over 240 lbs.

Weapons of Greater Power.	Gun.		None on hand.		
	Gun.	How.			
Superweapons.			240-mm. shell. Superquick and long-delay fuze.	Bore-safe fuze. Flashless propellant.	HE separate-loading flashless, superquick, and short-delay fuze. Not over 220 lbs.
	Gun.		8" and 10" ammunition on hand. Instantaneous and selective-delay fuzes.	Bore-safe fuze. Flashless propellant.	HE separate loading, flashless, bore-safe, instantaneous and selective-delay fuzes. Not over 400 lbs.
	How.		12" and 16" ammunition on hand. Instantaneous selective-delay fuze.	Bore-safe fuze. Flashless propellant.	HE separate-loading, flashless, bore-safe, instantaneous and selective-delay fuze. 240 lbs. for 8". 510 lbs. for 10".
					HE separate-loading, flashless, bore-safe, instantaneous and selective-delay fuze. 700 lbs. for 12". 1600 lbs. for 16".
Other Artillery	AA.		3" AA.	Mechanical fuze.	HE shell, fixed, flashless, mechanical fuze.
	In.		37-mm.		HE shell, instantaneous fuze. 10 lbs. shell.
	Trench.		None on hand.		50 lbs. projectile.
	Pack.		75-mm. Vickers.		HE and shrapnel, semifix, flashless, bore-safe, fuze.
	Antitank		37-mm.		75-mm. armor-piercing shell.

FIGURE 19.—Caliber Board's recommendation—ammunition.

TRANSPORT

		PRACTICAL	IDEAL
Light Field Artillery (Division).	Guns and howitzers.	6 Regts. 75-mm. guns should be motorized immediately (tractor-drawn). Remainder should be horsed. Present 155-mm. Hows. should be tractor-drawn. Horses should be gradually displaced by tractors only after tractor demonstrates its superiority.	Mechanical transport is the prime mover of the future. Experiments should be made with tractors, self-propelled mounts, and wheeled trailers. Speed of 12 mph is sufficient. Mechanical transport will remove the weight limit imposed by capacity of 6-horse team.
Medium Field Artillery (Corps).	Guns and howitzers.	All corps guns and howitzers should be tractor-drawn.	See above. Maximum speed 8 mph.
Heavy Field Artillery.	Guns and howitzers.	All artillery of this type should be tractor-drawn.	See above. Maximum speed 4 mph.
Weapons of Greater Power.	Guns and howitzers.	All artillery of this type should be tractor-drawn.	See above. Continue experiments with caterpillar mounts.
Superweapons.	Guns and howitzers.	Railway carriages.	Railway carriages, standard gauge, should conform to international clearance diagram, and should be provided with both American and French type couplings. A gas-electric, 400 horsepower engine should be developed.
Other artillery.	AA.		Caterpillar mount on caterpillar trailer mount. 12 mph.
	Inf.	Manpower.	In trucks on march. Manpower in battle.
	Trench		
	Pack.	Pack.	Pack.
	Antitank.		

FIGURE 20.—Caliber Board's recommendation—transport.

calibers, the cost of producing a liner is as great as the cost of producing an entire tube. On new carriages the divided type trail replaced the box trail, and the rear trunnion mounting of the barrel took the place of the balanced trunnion construction. These improvements inevitably resulted in increased weight and complication of the carriage.

d. Improvement in the strength and quality of steels and the technique of welding alloy steels permitted a lighter and simpler construction. The welding process replaced riveting to a large extent. By means of the auto-fretage or cold-working principle, it has been possible to produce monoblock tubes with sufficient strength to withstand the normal firing strains, at least in light and medium weapons. The production of small-caliber guns and howitzers by the centrifugal-casting method has been successfully accomplished, permitting a less expensive and faster manufacture than by forging. Further developments along these lines may result in the disappearance of the built-up, wire-wrapped, and removable-liner types, realizing at last the aspirations of Rodman with his cast-iron constructions.

e. In 1934 the republican form of government in Germany was overthrown by a new authority which adopted an aggressive foreign policy, denounced the restrictions of Versailles, and embarked upon a vast rearmament program. The artillery materiel at first utilized was a modification of World War types, but new designs soon began to appear. During the period of restrictions, German tactical doctrines stressed mechanization and mobility; since 1934 the trend seems to be back to power formations. Being forced by circumstances to rebuild practically from the ground up, the Germans were less influenced by World War stocks than other powers, and for that reason the characteristics of their new weapons is a matter for close study. The most important change disclosed to date is the replacement of the 77-mm. gun by the 105-mm. howitzer as the principal infantry-supporting weapon. The newer models are of the split-trail type. Although largely horse-drawn in actual service, they are fitted with high-speed spring-suspended running gear which adapts them to motor draft. Recently an 8-inch howitzer and a 10-inch gun have appeared in Germany. They are divisible into loads for motor transportation, and are said to possess superior characteristics from

the standpoint of mobility and range. Both light and heavy German antiaircraft weapons, especially an 88-mm. gun, proved highly successful in Spain. The German infantry division is organically equipped with large numbers of antitank guns of 37-mm. and 47-mm. caliber, and with special cannon for accompanying use, which are habitually attached to infantry units. These weapons are in addition to the mortars normally carried by infantry units. With the issue of a new light machine gun, the fire power of all calibers which is at the command of the German division far exceeds that of World War days.

61. Italian-Ethiopian campaign.—In the spring of 1936 the Italian army completed the conquest of Ethiopia. The war was marked by the extensive use of motor transportation in a mountainous region, which before the advance was almost entirely devoid of roads. The practicability of rapid highway construction was demonstrated. As a result of this campaign, all nations turned to experiments with a smaller but more mobile division. More detailed reports of the operations in Ethiopia, and the results of operations elsewhere, have indicated that much improvement in cross-country mobility is still necessary before the optimistic ideas of the speed of future warfare can be realized. Italy's achievements with motors in Africa were truly remarkable, but her success was in no small measure due to the skillful use of pack-animal transportation and native auxiliaries, and to the primitive training and resources of the enemy.

62. Japanese operations in Manchuria and China.—In Manchuria and China, from 1932 to date, Japanese forces have made deep advances into hostile territory in the face of superior numbers. Again the use of motor transportation has been successful in a country of poor roads. But, as in Ethiopia, the invaders possess a great superiority in materiel and organization, which prevents any accurate determination of the possibilities of mechanized forces in a conflict between first-class powers. The occupation of Canton by a whirlwind wide envelopment by mechanized forces demonstrated the possibilities of such units when the defense is demoralized. Japanese and Chinese materiel used in this war is largely of the World War type.

63. Spanish Civil War.—In Spain the idea of a successful mechanized operation unsupported by powerful artillery received a setback. It was conclusively demonstrated that comparatively weak defending forces can stop such attacks if the defense is intelligently and resolutely conducted. In Spain, conditions were soon reached which closely approximated the western front in the World War. Unsupported tanks were a failure. Bombardment aviation, although contributing materially to all operations, was not decisive. The tactics employed by General Franco in his victorious drives was that of the traditional infantry-artillery power team.

64. Field artillery in 1939.

a. Today, in all the artilleries of the world, the endless search continues to find the correct balance between range, projectile effectiveness, mobility, and economy. As the increased road speeds provided by modern motor transportation cannot be fully utilized on the actual battlefield in the face of modern gun fire and barriers, the tremendous weight-pulling ability of prime movers may be employed to transport heavier and more powerful weapons than have heretofore been possible in the infantry division. Sufficient mobility to accompany the supported troops must be retained. An incorrect guess as to the proper balance may be fatal to a nation which must be prepared for sudden war. Hence, all nations are influenced not only by their own secret investigations, but also by what their probable enemies are doing. The Germans, who abandoned the 77-mm. gun for the 105-mm. howitzer to secure more power, have lengthened the tube until it approaches the characteristics of a gun. The British, in reboring their 18-pounder gun to take a heavier projectile, have also modified their ammunition so as to give the weapon some of the advantages of a howitzer. It is possible that such compromises may result in weapons that are unsatisfactory for maximum effects from either a gun or a howitzer; the future may see a return to specialized types. Specialization restricts the capabilities of each individual weapon, but it provides a greater flexibility in the selection of positions and in the firing of missions for the artillery as a whole.

b. The French have recently adopted a light field howitzer of 105-mm. caliber. It is not known whether they will substitute it

for the heavier 155-mm. howitzer, or for the 75-mm. gun. By placing the 155-mm. howitzer in the corps or in GHQ reserve, France would gain mobility within the division, but would sacrifice power. These are problems of organization only; the types and total number of pieces in action on a given sector of front will determine the effect of fire. The new French 105-mm. howitzer incorporates some advanced principles in design. Cant of the carriage is corrected by a built-in leveling device on the axle. The projectiles fired are considerably longer than the conventional types; stability in flight is improved by the addition of a forward, copper, centering band.

c. The development of tanks has introduced a new type of cannon, the special antitank gun. Guns ranging from 20-mm. to 75-mm. are being employed by foreign armies. Events in China and Spain proved that against lightly armored tanks a small-caliber automatic weapon firing nonexplosive bullets is sufficient. But the medium tank of the future is expected to carry 1.5 to 2.0 inches of armor; heavy types are being experimented with that carry as much as four inches of armor. Against such land battleships a projectile as heavy as a 75-mm. shell, or even heavier, is necessary. This may be a contributing factor in the movement towards heavier calibers for divisional artillery. It is evident that all light and medium guns and howitzers must be designed for antitank use in emergency. For use against present light and medium tanks most countries are equipped with special, highly mobile, high-velocity guns of 37-mm. and 47-mm. caliber.

d. The designer of artillery materiel is vitally concerned in the result of existing experiments with specialized divisions, because weapons suited to the missions of these units must be developed. No uniformity is yet discernible as to a definite type of cannon for the mechanized division; that is, whether it is to be a conventional gun and carriage, a self-propelled type, or an armored self-propelled mount that is, to all intents and purposes, an artillery tank.

e. What may reasonably be expected in the way of improvements with existing types of materiel is an increase in fire power to take advantage of mechanical transportation, much improvement in cross-country mobility, and greater efficiency in ammuni-

tion and fuzes. Secrecy in such developments will be preserved for a brief time only.

f. In the year 1939, artillery armament in use by the major powers of the world may be placed in standard categories as follows:

(1) *Light*: 3.0- to 3.5-inch guns; 3.0- to 4.5-inch howitzers.

(2) *Medium*: 4-inch guns; 6-inch howitzers.

(3) *Heavy*: 6- to 10-inch guns; 8- to 12-inch howitzers and mortars.

(4) *Coast or fortress*: Guns, howitzers, and mortars of all calibers up to 16-inch.

(5) *Antiaircraft*: High-velocity guns from 1.5- to 4-inch.

(6) *Antitank*: Guns from 1.5- to 3-inch.

(7) *Infantry weapons*: Guns up to 1.5-inch; mortars up to 8-inch.

65. **Summary of the modern period (1897-1939).**—In 1897, with the appearance of the French 75-mm. gun, field artillery materiel assumed essentially its present form. In motor transportation, signal communication, chemical warfare, tanks, aviation, and automatic small arms, there were many and startling advances which vitally affected the artillery, and resulted in radical changes in tactics and technique. The World War forced a quantity production of all types of weapons, and the proportion of artillery cannon per thousand infantry was increased to a new high. Guns and carriages of the present day differ from those at the beginning of the period in having longer ranges, greater efficiency of ammunition, increased *strategic* mobility, and mechanical improvements that make for accuracy, stability, and faster firing. They have at the same time become far more complicated, more expensive, and heavier. New devices for locating hostile gun positions, both from the ground and sky, have been produced. Even a battery distinguished by its sound is in danger of destruction. A new type of projectile, the chemical shell, more than offsets the failure of shrapnel. The artillery barrage appeared, probably to stay, and in spite of prodigal expenditures of ammunition, massed fires centrally coordinated be-

came the rule in large operations. Artillery projectiles accounted for over 75 percent of battlefield casualties. Above all other auxiliary arms, field artillery became indispensable to the infantry in any important military enterprise, either offensive or defensive.

GENERAL SUMMARY

66. Recapitulation of periods.

a. By inscriptions on terra-cotta tiles in Mesopotamia and on stone monuments of Egypt, we know that empires rose and fell in the milleniums before the first engines of war were noted on the walls of Jerusalem. When such engines were invented no one knows. The written records of artillery go back only 2700 years. For the first 2000 years, missile-throwing machines consisted of variations of the ballista, catapult, and trebuchet, which threw balls to a maximum range of 600 yards.

b. With the appearance of gunpowder in Europe, about 1250 AD, a new form of energy was adopted. After the passage of 700 years we are still employing this principle. For the first four centuries developments proceeded mainly in the direction of caliber, until by about 1600 the smoothbore tube reached its maximum possibilities with black powder. Stone balls as large as 36 inches in diameter were fired from huge bombards in siege operations. In the open field, lighter and more portable cannon were used, firing case shot to an effective range of about 400 yards, and solid iron balls to a maximum range of 1500 yards. Artillery was a civilian monopoly little understood by the military profession, and maneuverability was neglected.

c. In 1631 Gustavus Adolphus brought about a revolution by introducing lighter and more mobile guns. Although range and effectiveness of projectiles were not much improved during the next two centuries, a development proceeded in mobility, organization, training and tactical handling of artillery which under the first Napoleon, gave to the arm an ascendancy in fire power.

d. Between 1860 and 1900 the preeminence was lost because of more rapid developments in small arms, but an evolution was in progress that was destined to restore the power of field artillery. The muzzle-loading bronze or iron smoothbore was re-

placed by a breech-loading rifled steel tube, black powder was replaced by smokeless powder and high explosives, and recoil mechanisms and other mechanical improvements were made on the carriage. Solid round shot, case, and grapeshot disappeared in favor of more efficient forms of ammunition which could be projected to four times the range of the smoothbore, and at a faster rate.

e. The modern period, including the World War and subsequent events to date, saw the rapid exploitation by the artillery of its new possibilities. Indirect fire was introduced, and other radical changes were accomplished to conform to discoveries in science and to the development of other military arms. In spite of contemporary advances in infantry weapons, artillery again dominated the scene in fire power.

67. **Field artillery's place in military science.**—A definition of field artillery that may fit all periods of history is that it is the arm of the military service, which by means of maneuverable devices emplaced on the ground, propels missiles that are too heavy to be employed by hand weapons. Artillery has used only three forms of energy in its machines; the elasticity of solids, the force of gravitation, and the elasticity of gas. It will be observed that the use of the cruder weapons extended for the longest period, perhaps 7000 years; that the compressed-gas tube phase in which we live is of comparatively brief duration, extending about 700 years, or one-tenth the preceding era; that the most revolutionary developments of the gunpowder period occurred during the most recent 70 years. Should this rate of accelerated evolution continue, remarkable developments may be expected within the service of artillerymen now living. It may be that the recent past was a phenomenon not to be sustained; the future may witness for an indefinite period only a relatively slow improvement of existing types. Although at the present time there appears on the horizon no serious rival to the supremacy of field artillery, the future may see other military agencies challenge again. Bombardment aviation, for instance, may restrict the development of extremely long-range guns. Science may discover how to harness forms of energy at present not susceptible of control, such as the energy of the atom.

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